THE

# FOUNDRY TRADE JOURNAL

*WITH WHICH IS INCORPORATED*

THE IRON AND STEEL TRADES JOURNAL

VOL. 64 — Thursday, April 3, 1941 — No. 1285

PUBLISHED WEEKLY

Subscription Terms (Home and Overseas) : 21s. per annum.
All Subscriptions are payable in advance.

THE FOUNDRY TRADE JOURNAL
49, Wellington Street, London, W.C.2.

WARTIME ADDRESS
to which all communications should be sent until further notice :—
3, Amersham Road, HIGH WYCOMBE, Bucks.
Telegraphic Address : "Zacatecas, High Wycombe."
Telephone : HIGH WYCOMBE 1792 (3 lines).

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## *Finished Jobs?*

The metallurgist and chemist are both well aware of the difficulties to be associated with the determination of the end point in reactions, yet when either a personality of high scientific attainments or a lesser light commanding a wealth of well authenticated research data, propounds a "finished theory," acceptance without question follows for periods of varying lengths. Such complete acceptance is often productive of much good, for there is a concentration of brain power towards utilitarian development. Prof. Arnold's short-lived "sub-carbide theory" helped the practical hardener to improve his craftsmanship. Prof. Turner's epoch-making research on the influence of silicon on cast iron formed the basis of quasi-scientific control in the iron foundry for several decades. In fact, this research carried such "finish" that it caused this particular field to lie fallow for too long a period. In more recent times, in another industry, that of vitreous enamelling, a brilliant piece of research work has been undertaken by Zapffe and Sims, who, after extensive and somewhat novel experimentation, backed up by sound logic, have shown how practically all the defects in enamel coatings can be traced to the presence of hydrogen in the enamelling stock. That their theories will receive acceptance in many quarters can be regarded as a *sine qua non*. Their permanency or duration will depend on whether their application results in a consistently better product and whether a "Jones" or "Smith" produces an equally well-finished piece of research work based on some other well-founded premise.

If the telescoping of industries impacts in any great measure of force upon the foundry industry, there will be some heart-burning, for foundry managers, like research workers, have from time to time produced their equivalents to "finished researches." With the new order of affairs, the elasticity of the model plants will be tested to the utmost. The entry of new patterns will arouse criticism either of the newcomers or those already in commission. There are some very large concerns in the light castings industry operating in some cases more than a dozen foundries. Obviously, they lend themselves excellently to "telescoping" with a minimum of ill-effects from a long-term outlook. Generally speaking, in these corporations, there has been financial integration only, and each unit has been left to develop its own technique, unless financial results dictated investigation and reorganisation. Actually, attempts at technical co-operation were not, in all cases, welcomed by the individual managers. Now, *force majeure*, it will be attained. The telescoping of industries, does not mean, so far as foundry activities are concerned, the closing down of any works, for the Act is designed to render available more men and more floor space for the making of munitions. To a large extent, this action has been in progress ever since hostilities broke out, and managers, who with good reason thought they had produced the "finished article" for the economic manufacture of castings, have had a rude awakening. Insufficient plant of a heavy type, inadequate fettling space, and a deficiency in core-drying ovens have been encountered in different works. This is no criticism of the plant originally installed, but a pointer, designed to show that a "model" foundry, like the "finished" piece of research work, has but a limited life. Their creation and exposition do much good for varying periods, depending on their worth, novelty, soundness of appeal and general application, but few will withstand the prolonged attack of scientific research and engineering progress.

Changes consequent upon telescoping will be profound in their incidence. It is inevitable that they will broaden the outlook of many foundry executives, through the enlargement of their experience. Many well-established notions, based on "finished" researches, will be rudely shattered, yet the industry as a whole will benefit.

# Metals on the Move

By "Onlooker."

There is not nearly so much heard nowadays about hoarding of scrap metals, possibly because consumers are securing all they want in the way of raw materials, the bulk of it being in the form of virgin material. Whether or not during the early days of the war there was a tendency to hold on to stocks of secondary metals cannot be said with certainty, but the chances are that with the future of prices very uncertain some accumulation did take place. In December, 1939, the values of non-ferrous metals advanced sharply, and for a time thereafter many people connected with the trade believed that this was only the beginning of a strong upward movement, but as the months went by without this expectation being fulfilled sentiment weakened and stability was accepted as a settled condition, at any rate for the period of the war. There was no longer therefore any particular reason for hoarding scrap, and probably the downward trend of American copper prices during the third quarter of the year gave rise to misgivings about the future of values here. Moreover the collapse of France released a certain amount of tonnage in the shape of copper, spelter, etc., originally destined for that country to swell our imports into Britain, and it was not long before the scrap merchants sensed this change in the situation and began to trim their sails accordingly. It may well be that this change of heart was the means of eliminating the last tendencies to holding back secondary metal from consumption.

Since then there has been something of a scare over the residues situation, for from time to time during the past few months it has been stated that low grade material was accumulating to a dangerous extent. The rights and wrongs of this matter are not at all easy to determine, but it might not be a long way from the truth to imagine that the danger envisaged was more for those holding the residues than from the national viewpoint of total metal supplies. In any case the Controller of Non-ferrous Metals, in promulgating schemes to purchase blister copper and brass ingots, took steps to test the situation and probe the truth, for the prices offered for these products are not in near relation to new metal values for a very good reason. If these lower grades of secondary metal are selling freely then the prices obtained would put them out of the running for absorption under the Controller's scheme, but granted that there is a glut, then their valuation should decline to a point at which the copper refineries and the foundries would purchase for conversion and resale to the Ministry of Supply. What the response has been is known only to the authorities, but market opinion is that there has not been much business passing since the plan was put into operation. It is, of course, realised that in pre-war days a considerable export business was done with Continental houses in this type of secondary material.

There is, however, another way in which a hold up in metals may occur, and this has nothing to do with the producers or distributors of scrap. Most fabricators have, as a result of greatly increased outputs, been obliged to expand their stock in process, and there is always the chance that this inflated tonnage may include metal which has become as it were sidetracked for one reason and another. Shapes and sizes no longer in demand may be kept in reserve in case the call for them should return, and this means a hold up in the turnover and is equivalent to hoarding. With shipping so heavily taxed to carry essential raw materials to these shores every ton matters, and manufacturers should see to it that their stock is kept one hundred per cent. on the move, for only thus can our war effort be kept at its maximum.

## The Late Mr. Sidney G. Smith

As briefly announced last week, the death of Mr. Sidney G. Smith occurred in Manchester on March 18. Mr. Smith entered the foundry industry at a very early age as an apprentice; he made the most of his opportunities, both to obtain practical experience and technical knowledge, and he eventually achieved a considerable reputation both as a practical foundryman and as a writer on technical subjects. He held positions with various firms, including the Staveley Coal & Iron Company, Limited; Cole, Marchant & Morley, of Bradford, and in 1914 became assistant superintendent of foundries to the British Westinghouse Electric & Manufacturing Company, now Metropolitan Vickers Electrical Company, Limited. He remained with this company in this capacity and as consultant for some twelve years, and then established himself as a foundry consultant. In recent years he had lived in retirement.

He joined the Institute of British Foundrymen in 1909, and some few years ago he was elected a honorary life member. He was a Past-President of the Lancashire Branch of the Institute. He was one of the first foundrymen to apply modern metallurgy to practical foundry operations, and he wrote and lectured extensively for many years. He was a regular contributor to the columns of this Journal, and he presented many Papers to the Institute of British Foundrymen. It can now be disclosed that Mr. Smith was the author of the "Students' Corner," which was such a popular feature of the Journal some few years ago. With the memories of his own early struggles, he was keen to promote facilities for training foundry apprentices, and for several years he conducted classes for apprentices in Manchester, Stockport and other towns in the neighbourhood. Mrs. Smith predeceased him by a few days.

## New A.F.A. Officers

The Council of the American Foundrymen's Association has nominated for election at the annual convention to be held in New York City the week of May 12 to 15, the following:—

*President:* Mr. H. S. Simpson, President, National Engineering Company, Chicago.

*Vice-President:* Mr. Duncan P. Forbes, President and general manager, Gunite Foundries Corporation, Rockford, Ill.

*Directors to serve three years:* Mr. L. N. Shannon, vice-president and works manager, Stockham Pipe Fittings Company, Birmingham, Ala.; Mr. M. J. Gregory, factory manager, Foundry Division, Caterpillar Tractor Company, Peoria, Ill.; Mr. Wm. J. Corbett, vice-president and works manager, Atlas Steel Casting Company, Buffalo, N.Y.; Mr. James G. Coffman, plant manager, Los Angeles Steel Casting Company, Los Angeles, Calif.; and Mr. R. J. Allen, metallurgist, Worthington Pump & Machinery Corporation, Harrison, N.J.

## Notes from the Branches

*Wales, Monmouth and West of England Branch.*—The Annual General Meeting is to be held at the South Wales Institute of Engineers, Park Place, Cardiff, at 4 p.m., on April 5, to elect officers for the ensuing twelve months and any such business as may be of interest to the Branch and Institute. An address will be given by the Branch-President, Mr. S. Protheroe.

*West Riding of Yorkshire Branch.*—A meeting of the members is to be held at the Technical College, Bradford, on April 5, 1941, at 6.30 p.m., when a Paper will be given by Mr. A. E. McRae Smith, M.A., on "High Duty Alloy Iron Castings." The Annual General Meeting and election of officers will be held at the Technical College, Bradford, on April 26.

# Random Shots

Those Londoners who are in a position to take an occasional brief rest from the regions of work—and there should, happily, be many this Easter—are lucky in having a place like Kew Gardens within reach to remind them that Spring is beginning to bud and colourful flowers to show. There is special reason this Spring to be grateful for the delights of Kew; for not only does it provide a pleasant change of vista from the present feathery carrot tops and blousy cabbage plants of one's own garden, but it happens to be just one hundred years ago this very week since Queen Victoria presented the gardens to the nation.

* * *

Incidentally some eighteen months before the war started "Marksman" had occasion to entertain a very young and enthusiastic Nazi in London, which round of entertainment naturally included a visit to Kew. It is worth noting that what impressed that devotee of Hitlerism, with its ideals of slavery, was not so much the perfect blooms as the complete freedom in which one could roam about the lawns and glades without ever a "verboten" to restrict one's movements.

* * *

It is amusing, too, to note a little economy notion that has been put into practice in some of the other parks. Whilst the "Please keep off the grass" notices have been repainted white, the "please" has been left unpainted! It would be interesting to know just how much paint is saved in this way, and a point could be raised as to whether that saving is so considerable as to justify the loss in the spirit of courtesy.

* * *

Two workmen, laden with gasmask, helmet, and toolbag, climbed on to a London bus. One was successful in getting a seat at once at the side of a small but pretty girl, whilst the other had to struggle to the front of the bus only to find standing room. Noticing where his mate was sitting so snugly, he called out, "Are you quite comfortable there, Bill?" "Aye," answered Bill with quick Cockney repartee, "but I don't think I can get into my jacket pocket."

* * *

A little girl was travelling on top of a bus with her mother. It was evidently a new route to her, for she was obviously excited over the unaccustomed sights. A large block of barrack buildings seemed particularly impressive, for she continually plied her mother with questions about it. "And look, mummy," the shrill childish voice piped out, "Isn't Private Cars lucky? He's got a gate to go into all to himself!"

* * *

*This week's quiz:*—

(*a*) Hysteresis is—a kind of fit; a town in Greece; a physical characteristic; an electrical instrument.

(*b*) Cybotaxis is—a trade name of a motor hire firm; a skin condition of castings; transitory nucleii in molten metal.

(*c*) Hardfacing technique is—a special canteen method of cooking steak; a process of surface welding; a method of resisting the wiles of the latest pretty typist; mould sleeking.

* * *

*Answers to last week's quiz:*—

(*a*) Colonel Appleyard, who is now a Major-General. He was President of the Newcastle Branch.

(*b*) Mr. S. H. Russell, and Mr. V. C. Faulkner.

(*c*) Mr. F. J. Cook, Dr. Longmuir, Mr. R. W. Kenyon, Mr. J. Galt.

(*d*) The Right Honourable Arthur Henderson.

(*e*) Sir Robert Hadfield, Bt., in 1935, and Viscount Nuffield, O.B.E., in 1937.

"Marksman."

# Efficient Control and Disposal of Swarf and Scrap Metal*

By D. F. GALLOWAY, Whit.Sc., B.Sc.

### Factors and Processes Involved

Ever-increasing production, and the growing demand for a strict economy in material during the war emergency has focussed the attention of most production engineers on the problem of economic swarf disposal and the efficient recovery of scrap metal. Some firms already have highly efficient systems for handling swarf and scrap, but many firms must now begin to give this problem greater attention as the urgency for conservation of material grows. The problem of handling swarf has no universal solution which is suitable under all circumstances. Many of the factors which govern the most economic production of a job also apply to the problem of economic swarf disposal, for the most suitable procedure will depend on the material of which the scrap is composed, brass, bronze, steel, cast-iron, etc., the total quantities of scrap involved, the rate of production of scrap, the form of the scrap, small chips, long streamers, scrap workpieces, metal plate or strip, etc. Another relevant factor is purity of scrap, *i.e.*, whether it consists entirely of one material or is a mixture of several metals. Yet another factor is the method of scrap disposal for recovery of the material, *i.e.*, whether the metal is to be sold to a dealer for remelting or whether the firm is to remelt it for their own foundry. Only

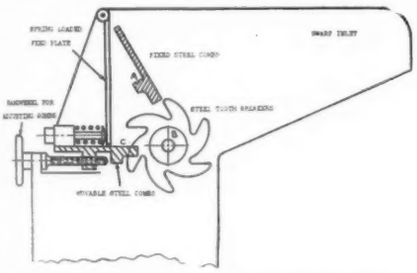

FIG. 1.—DIAGRAM OF SWARF CRUSHING MACHINE.

when all the foregoing factors have been thoroughly investigated and carefully considered is it possible to prescribe the most efficient method of scrap disposal for any particular case.

Before the economics of scrap disposal can be considered it is necessary to have a clear conception of the processes involved and the various means available for performing each stage of the disposal. The sequence is approximately as follows:—(1) Initial control of scrap metal as it is removed from the bar or strip, leaving the required workpiece; (2) immediate storage of swarf in or near machine base; (3) removal of scrap to main storage or sorting department; (4) separation of coolant from swarf and breaking if necessary; (5) sorting of different materials if necessary, and (6) baling, storage, and removal to melting plant.

### Swarf Breaking

Some swarf such as that produced when turning or drilling steel takes the form of long curled strips. These spirals often become difficult to handle, and if much of this coarser swarf has to be dealt with it is desirable to have it broken up. A machine suitable for swarf breaking is shown in Fig. 1. It consists of a series of rotating breakers B, the teeth of which pass between the teeth of a stationary cutting comb C. The swarf is carried between the rotating breaker teeth, past a fixed comb A which regulates the feed to the cutting comb C. The position of the cutting comb is adjustable by a hand wheel to suit the chips dealt with. A spring-loaded friction clutch drive can be arranged to slip at any predetermined load so that the introduction of a solid article such as scrap work piece, key, file, etc., stops the machine without damaging any part of the gearing or breaking teeth.

Another powerful type of swarf breaker is that shown in Fig. 2. In this crusher the swarf is fed in heaps into the side of the hopper and falls on to the rotor. The teeth of the rotor are pivoted, but are held in their outer crushing position by centrifugal force. They grip the swarf and force it past the spring-loaded breaker block and then through the grid which surrounds the lower part of the rotor. The path of the swarf is indicated by dotted lines. The grid bars are made of high carbon steel and the crushing elements of heat-treated cast-alloy steel with wear resisting tips welded on. Instead of teeth the rotor can be fitted with

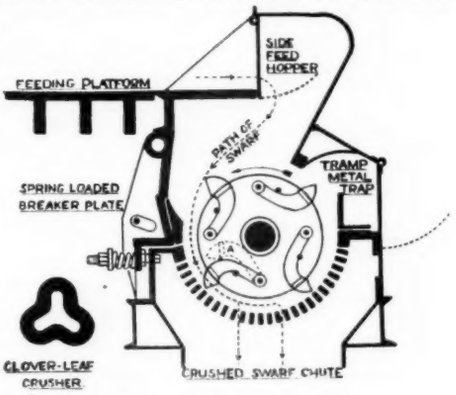


FIG. 2.—SWARF CRUSHER.

crushers of the clover leaf form shown on the left-hand side of Fig. 2. These manganese steel rings are also maintained in their outer crushing position by centrifugal force. Ample provision is made in this crusher to avoid damage which may be incurred by the inclusion of "tramp metal" in the swarf. The crusher teeth or clover leaf steel rings are free to recede into the rotor as shown at A, Fig. 2, if they come into contact with solid metal having sufficient resistance to overcome the centrifugal force which maintains the crushing elements in their working position. Moreover, the breaker plate is spring-loaded to prevent excessive shock at that point. In addition to these safety features there is a special built-in "tramp metal" catcher, and in pulley driven machines a shear-pin device is also included. Where it is more convenient a top feed hopper can be arranged to replace the side feed hopper shown above. Some form of hopper closed by a flap is essential because, when there is only a small quantity of swarf in the machine there is a tendency to fling this out and endanger workers. The speed of these machines varies from 500 to 900 r.p.m. and the power consumption from 25 h.p. for a machine crushing one ton of chips per hr. to 75 h.p. for a machine crushing six tons of chips per hr.

In addition to separate chip breaking machines such as those described above there are also mechanisms for chip breaking which are built into machine tools. For example, some special automatic machines for rapid turning incorporate devices for breaking and baling swarf which is immediately delivered in a compact form ready for transport.

### Swarf Sorting

In some workshops where very varied work is encountered, it becomes impracticable to keep all swarf of different materials separate, so that mixtures of brass, steel, aluminium, cast iron, etc., have frequently to be handled. It is essential to separate these before remelting, if strict economy and effective conservation of materials are to be attained. Various forms of sorting machines are available. The type of machine to be selected depends on the materials to be separated, the approximate percentage of iron and steel content of the mixture, the approximate size of the swarf handled, and the the rate of separation required. Reliable Universal machines are available which will effectively separate the most varied mixtures, but if the material to be handled is known to consist of small chips, or to be of powder form, or to contain not more than, say, 10 per cent. iron and steel, such information facilitates the selec-

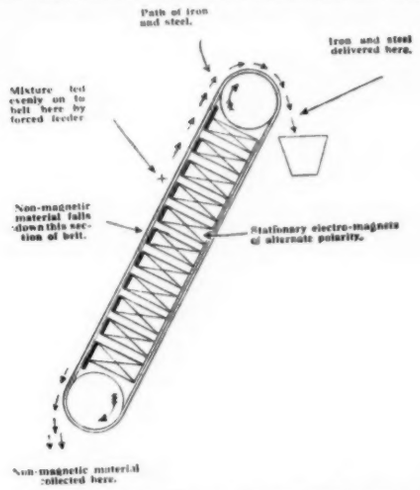
Path of iron and steel.
Iron and steel delivered here.
Mixture fed evenly on to belt here by forced feeder
Non-magnetic material falls down this section of belt.
Stationary electro-magnets of alternate polarity.
Non-magnetic material collected here.

FIG. 3.—OPERATION OF ELECTRO-MAGNETIC SEPARATOR.

tion of simpler machines than those required for the more general tasks.

A machine suitable for the most varied separation is shown in Fig. 3. This magnetic separator is designed to deal with coarse or fine swarf and to remove the iron content whatever its percentage of the whole. The machine consists of a belt in which a large number of steel inserts are arranged in staggered rows. The belt passes over two pulleys set in an adjustable frame so that the inclination of the straight portion of the belt can be arranged to suit the materials being separated. A series of stationary electro-magnets of alternate polarity are located beneath the length of belt moving upward, so that inserts passing through the field are subject to alternating polarity. Iron chips attracted to the magnetised inserts jump from one insert to the next as the belt moves over alternate magnetic poles. This jumping action disturbs the material and thus frees non-magnetic particles which fall down the belt shute, while iron and steel are carried to the top of the shute. As the belt passes over the upper pulley the inserts lose their magnetism, and the extracted iron falls by gravity into the upper container. Thus the mixture is fed to the belt shute at X, the iron is collected at the top and the remainder at the bottom. The capacity of these machines is varied by varying the width of the belt. Since the process of separation does not involve a

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* Extracted from a Paper presented to the Institution of Production Engineers.

vibrating shute, the framework is not subject to vibration stresses. This not only ensures long life by eliminating vibration of the magnet coils and ball-bearings, but also obviates the necessity of foundations or even of bolting the machine down, and facilitates modification to make the machine portable.

A simpler type of machine suitable for separating iron and steel from non-magnetic materials consists of powerful electro-magnets enclosed in a brass drum. The magnets which create a strong magnetic field round the front half of the drum remain stationary, while the drum itself rotates. The mixture is fed at a uniform rate from the hopper above the drum, and separation is effected by the non-magnetic material falling from the drum at the front of the machine and passing down the diverting shute, while the iron and steel cling to the drum until they are released in the demagnetising region at the back of the machine. Experience

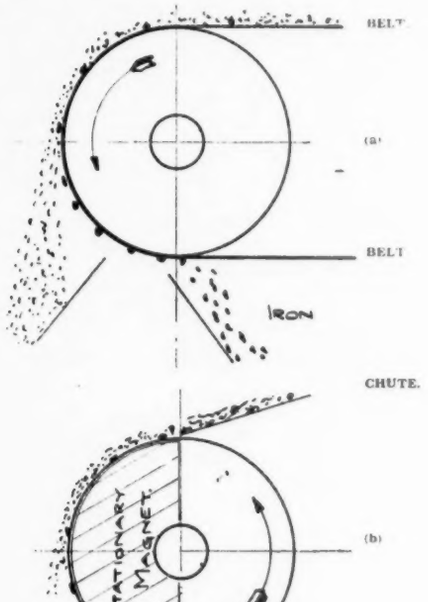


Fig. 4.—Showing Difference between (a) Magnetic Pulley and (b) Magnetic Drum.

has shown that the most convenient drum diameter is 14 in., and the output of the single drum machine is about 2 cwts. per hr. for each 6 in. width of drum, the corresponding power consumption being approximately 100 watts. The precise output is of course dependent upon the nature of the mixture. The hopper is of the oscillating tray type. About 95 per cent. of the magnetic material is extracted from the mixture by passing over the drum once, and if more complete separation is required the material should be retreated, or a machine having two drums should be used (Fig. 4). This drum type of machine is particularly suitable for the separation of mixtures containing more than 3 per cent. iron and steel. It is not advisable to use the separator for mixtures having an iron content of less than 3 per cent., because the thickness of the brass drum and the clearance between the drum and the magnets reduce the pull on the passing iron and steel chips and make the extraction of fine particles very difficult.

Many types of magnetic separating drums and pulleys exist, and it is essential to appreciate the fundamental differences between the various kinds if a correct choice is to be made. The most important difference is that materials separated by a magnetic pulley (Fig. 4a) do not come into contact with the pulley because of the intervening belt, whereas materials treated by a magnetic drum (Fig. 4b) do come into direct contact with the drum surface.

The entire cylindrical face of a magnetic pulley (Fig. 4a) is surrounded by a constant magnetic field. The mixture to be separated is carried on a belt, which discharges the non-magnetic material as it passes down the outside of the pulley, while the magnetic material clings

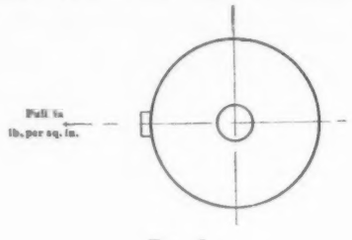


Fig. 5.

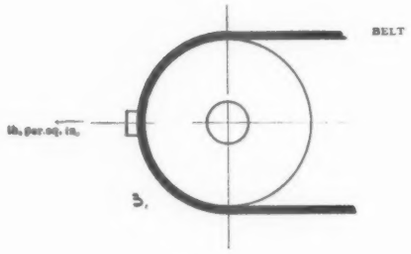


Fig. 6.

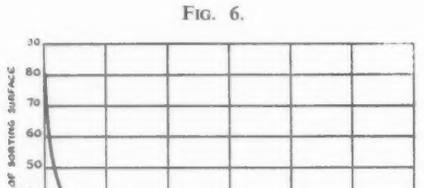


Fig. 7.—Reduction of Magnetic Pull due to Increasing Belt Thickness.

to the belt and is only released when the latter parts from the pulley on the lower side (Fig. 4a). A great disadvantage of the magnetic pulley is that even the thinnest belt prevents the extracted iron reaching the strongest part of the magnetic field. It is obvious that with this magnetic system it is impossible to dispense with the belt, for the iron would then continue to cling to the pulley and would not be forced out of the magnetic field and discharged. To demonstrate the effect of belt thickness on the effective magnetic pull, experiments were conducted as shown in Figs. 5 and 6. The pull per square inch of surface was measured for various belt thicknesses from zero to $\frac{3}{16}$ of an inch. The results are shown in Fig. 7.

There are several types of magnetic drums. The most usual is that described above (Fig. 4b), in which a stationary magnetic field extending round half the drum circumference allows the non-magnetic material to fall as it passes through the magnetic field and releases the iron and steel as it passes to the non-magnetic region. One disadvantage of this simple type of drum is that a piece of non-magnetic material which happens to be between a piece of iron and the drum surface as it enters the magnetic field may be trapped and held until the iron and with it the trapped material fall off in the non-magnetic region. This difficulty has been overcome in some types of drum separators by replacing the constant magnetic field by a series of fields of alternating polarity.

The vibrating trough electro-magnetic separator (Fig. 8) is specially designed for the separation of mixtures in which the iron and steel content is less than 3 per cent. and which take the form of very small chips or powder. As stated above, such materials are difficult to handle on drum-type machines and cannot easily be fed down stationary shutes. The machines consist of a vibrating inclined tray made of non-magnetic material and carrying steel bars which are magnetised by induction from stationary primary coils situated below. The mixture to be separated is fed into the hopper at the top of the inclined trough and slides evenly over a

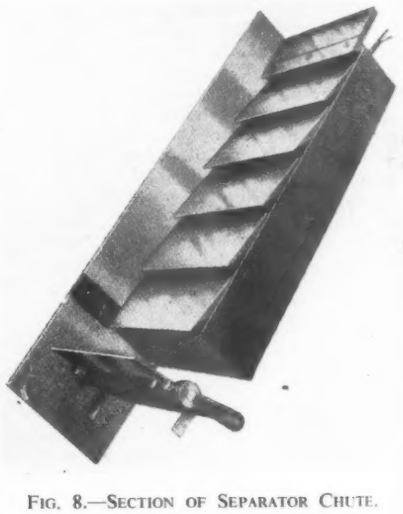

Fig. 8.—Section of Separator Chute.

series of magnets which oscillate in the direction of the flow. The iron and steel particles cling to the powerful magnets, while the non-magnetic material passes down the trough and is discharged at the foot. When the magnets are fully loaded the machine must be stopped while the iron and steel is removed from the trough. It is for this reason that the machine is not recommended for the separation of mixtures containing more than 3 per cent. iron and steel which would result in quick loading of the magnets and in frequent stoppages for cleaning. The minimum number of magnetic units to give good separation is three, but additional units can easily be incorporated if more complete separation is required. The output of the machine is dependent on the width of the trough, which is usually between 6 in. and 24 in. The tray and magnet bars are the only oscillating parts, the remainder of the magnetic system and the trough sides being free and stationary. This not only reduces wear of bearings and coils, but also obviates the necessity of heavy foundations, so that the machines can readily be made portable. The general form of the shutes used in these separators is illustrated in Fig. 8, which shows the shute of a stationary waterfall separator with the side removed. In selecting a magnetic separator for a particular job, recriminations and unreasonable maintenance charges can be avoided by ensuring that vibrating parts of the machine have adequate bearing surfaces, and that coils are not subjected to excessive vibration.

*(To be continued.)*

# Melting and Casting Problems

## A LANCASHIRE DISCUSSION

Mr. A. E. McRae Smith's Paper on Melting and Casting Problems in the Production of High Strength and Special Duty Alloy Iron Castings, which was printed in our last issue, had a very enthusiastic reception when it was presented to the Lancashire Branch of the Institute of British Foundrymen. What follows is an abstract of the discussion consequent upon its presentation.

### Melting Losses

MR. C. R. VAN DER BEN congratulated Mr. McRae Smith on the way in which he had dealt with the subject of high-duty cast irons, and the development of the acicular or pseudo-martensitic structures, which, besides being one of the latest phases in the production of cast irons, was of extreme importance. Mr. McRae Smith knew that the company with which he (the speaker) was associated, was probably one of the first in the country to undertake the manufacture of such high-duty cast irons. Their extraordinary toughness was undoubtedly a particularly outstanding feature.

Mention had been made of the loss of carbon on melting in rotary furnaces. Personally, he had not had that experience. He was operating a rotary furnace and the loss of total carbon involved was negligible. The question of adjusting total carbon in such an iron was a different matter. This was found to be a difficulty, but the actual loss of carbon itself was not a serious factor.

Stress had been laid on the fact that high-duty cast irons could be produced of the order of 3 per cent. total carbon or even more. This, apparently, was extremely important, for every point below 3 per cent. doubled the founder's difficulties. He thought that was the general opinion nowadays.

### Cupola Operation

A serious practical point to be noted in connection with the production of high-strength irons in the cupola had reference to the operating conditions necessary to be developed in the cupola. If a cupola were run entirely for such irons, then everyone in the foundry could be happy, but if about two tons of high-duty iron were required, and then only common irons in the afternoon, the foundryman was faced with a difficulty. The normal operating conditions of the cupola would not meet the case for a 2.9 per cent. carbon iron. If any attempt were made to modify the cupola conditions in the middle of a blow, the desired iron would not be obtainable, and there could be no casting from the cupola for the rest of the day. In many cases the difficulty was solved by the use of a small separately-melted charge of very low-carbon material, which could be added to the normal cupola 3.3 per cent. carbon iron. This was a very convenient way of obtaining 3 per cent. carbon iron from a cupola.

Mention had been made of the standard size of the metal charge in relation to a depth of coke of about 6 to 8 in., and the loading of 8-cwt. metal charges with a 48-in. cupola. He feared that Mr. McRae Smith would not get 6 to 8 in. of coke in such a case.

The development of the acicular structure had been made possible through the use of molybdenum in irons. He had personally spent a considerable amount of time developing molybdenum irons, and then with the usual human perversity had tried to eliminate them. He believed it was possible to produce a pseudo-martensitic structure without the use of any alloy.

### Properties of the New Irons

MR. MCRAE SMITH said that Mr. van der Ben was one of the pioneers in this country who had dealt with the acicular structure of cast iron. There had been quite a considerable amount of work done in America, though it was not done in exactly the same way that Mr. van der Ben had been doing his. This work was now being developed in this country for what might be termed war-time uses. He would like definitely to stress the fact that it was the toughest form of high-strength true cast iron obtainable, and its properties were rather amazing.

### Carbon Losses in Rotary Furnaces

With regard to loss of carbon in rotary furnaces, he noted that Mr. van der Ben had not experienced any excessive loss. Perhaps his own remarks had not been sufficiently clear concerning this point. What he really meant was that, in order to obtain in a rotary furnace a cast iron of about 3 per cent. total carbon content, much steel scrap could not be used, because there was extreme difficulty in recarbonising a charge in a rotary furnace. He had to deal with such cases from time to time, and he was aware of instances where foundries had tried to recarbonise with hard gas carbon, but attempts were never very successful. It should be borne in mind, however, that he was not seeking to criticise the uses of the rotary furnace, although they had heard a great deal in the earlier days of rotary furnaces that it would be possible to melt 100 per cent. borings and all the "muck" left over in foundry yards and still obtain good castings; yet in certain furnaces in the country the carbon loss was very considerable. He was aware of other cases, in addition to that of Mr. van der Ben, where this was not so. At the same time, one could not run a 60 to 70 per cent. steel charge in a rotary furnace and get 2.5 to 2.8 per cent. total carbon.

He agreed that when really high-strength irons with 3.1 per cent. total carbon could be obtained it was very desirable, because their castability was very good. If one carried inoculation or late silicon addition or addition of other graphitisers to a degree greater than that which was originally intended, instead of adding 0.3 to 0.5 per cent. silicon, when thinking of irons of 2.6 to 2.8 per cent. total carbon range, this enabled one to get a balance up to about 3 per cent. silicon. If up to 1 per cent. of the silicon was added in the form of late silicon addition, then the castability was really good; otherwise he agreed with Mr. van der Ben that for every 0.1 per cent. of carbon reduction, foundry troubles were greatly increased. Carbon-silicon balance must be maintained if good castability was also to be retained.

### Meeting Variable Demands

Actually he intended to speak about the question of making small quantities, say 2 tons, of high-duty cast irons along with other work, but he had had to curtail his Paper somewhat. Nevertheless, it did present a great difficulty. In the case where, with a 4 tons per hr. cupola, only 2 tons of metal were required, if high-duty iron was to be produced, it was very handy to be able to make a little synthetic pig-iron with the first ton of material. After that it was not difficult, and the required number of charges were put on in order to get the 2 tons of iron. There was great difficulty, however, if the 2 tons of special iron were charged during the middle of a blow.

A great many foundrymen were still of the opinion that if about 50 lbs. of coke were put on as an extra split, then the trouble was over. It would be found, however, after running on a high-phosphorus iron after a low one, that the phosphoric iron had crept down the cupola, and there would be about 0.6 or 0.8 per cent. of phosphorus in the high-duty iron. There were two practical methods of dealing with it. One was simply to blow down, re-establish the bed, and charge again. The other way was to have a low-phosphorus iron or type of iron as near as possible in base composition to the high-duty cast iron to follow, and then go over to the common, higher phosphorus grade.

With regard to duplexing, a small electric or even an oil-fired crucible furnace might be very useful in order to make a really low-carbon material of 1.0 to 1.5 per cent. total carbon, preferably if using alloys, and mixing the correct proportion of this with a cupola metal of about 3.2 to 3.3 per cent. total carbon.

He might have been somewhat mistaken in mentioning 8 cwts. He forgot whence he obtained the actual figure. As a matter of fact, he thought it was a mistake for a 48-in. cupola, and he would check the figure. It should be borne in mind that he was speaking of an 80 per cent. steel-mix charge and the coke ratio would be high.

### Stress Relieving

In regard to Mr. van der Ben's statement concerning the development of acicular structures without alloys, he was aware that there might be important possibilities in that line before very long. Perhaps suitable heat-treatments might give acicular structures. His own idea was to produce the high qualities in cast iron "as cast." By all means give stress-relief annealing at a temperature of 400 to 450 deg. C., and on soaking eliminate internal stress, which was an artificial way of doing what engineers used to do by weathering castings for long periods.

### The Rôle of Phosphorus

MR. E. LONGDEN said that the strength of cast iron depended upon the constituents present, particularly carbon. The lower the percentage of phosphorus the stronger the iron would be, other factors being equal. The useful upper phosphorus limit shown on the graph was around 0.3 per cent. Was it possible to understand the mechanism of this beneficial effect of something like 0.3 per cent. of phosphorus? Was it because the metal had better feeding properties? It was known that short freezing ranges caused a closer grain. This part of the action of phosphorus was not quite clear to him, and he would be grateful for any information which could be imparted.

It was noted that Mr. McRae Smith was not demanding the operation of cupolas on economical lines. The coke consumption to the author was not a matter of any great importance, and it was to be agreed that the first and most important matter for consideration was the best quality of iron. It was noticeable, however, that while using quite considerable quantities of coke, Mr. McRae Smith obtained low-carbon irons. This was due to the rapid rate of melting. Mr. Longden assumed that the blast was increased over normal theoretical ratios, etc.

### The Newer Range of Irons

There were many types of high-duty irons on the market, but the latest development was something of an eye-opener with regard to strength. Having referred to Ni-Tensyl iron, Mr. Longden then mentioned that Meehanite would give a tensile strength of 20 to 28 tons.

### Hot Mould Irons

Reference had been made to hot-mould irons which were really not very high-tensile irons.

but which gave a tensile strength of something like 18 to 20 tons and were remarkably resistant to impact. Hot-mould iron was definitely of a very high order and standard so far as impact values were concerned. One could suggest anything between 10 or 1,000 per cent. more in yield. They were remarkable irons for withstanding impact values, and he could say that from experience. Another iron which was definitely a low-carbon iron should be really beyond the definition of cast iron, *i.e.*, Corsalli iron, for which 60 tons per sq. in. was claimed. It was to be presumed that that figure would relate to heat-treated iron, where the greater strengths were obtained with pearlitic structures.

There was a special high-duty iron which had a high silicon content of 3 per cent. and a high carbon content of 3.5 per cent. There was no pearlite, and yet there was a high-strength material of up to 28 to 30 tons. Thus high-duty cast irons were being very much developed, and great credit was due to those who had brought about this latest form of high-duty cast iron.

### Phosphorus Content and Physical Properties

MR. MCRAE SMITH was pleased that Mr. Longden had mentioned the 0.3 per cent. phosphorus content, but it was something about which he could not give a definite answer. He did know that it was a fact and the graphs incidentally had shown this rather well. It was a point upon which work was being done at the present time in connection with high-duty irons. He was inclined to agree that the difference between 0.1 per cent. and 0.3 per cent. phosphorus might extend the freezing range in the same way as different amounts of phosphorus in a phosphor bronze extended it. It might give some degree of extra feeding quality and thus produce a sounder structure of greater strength. This referred only to pearlitic cast irons and not to the acicular structure irons.

The strength of the cast iron mentioned was dependent upon the strength of the matrix, and this was broken up by graphite. The breaking up by graphite did not necessarily mean that it had to be small and fine graphite, as everyone was inclined to think at one time. It must be a random, ragged structure which permitted the matrix to do its work and withstand stresses.

### Coke Consumption

With regard to coke consumption, he had mentioned a 36-in. to 48-in. coke bed. This was essential as a pre-heating device. It was not for melting the metal, and the bed reached its own level. The split coke should not be much greater than that required for ordinary phosphoric cast iron, except that allowance must be made for the absorption of carbon into the steel.

Regarding impact tests on a hot-mould iron, he knew Mr. Laing would agree with him that the single-blow Izod impact type of bar shown was really developed in connection with Lanz-Perlit iron. Although some extremely high figures had been obtained by the Lanz process, particularly with Izod bars taken out of billets 8 or 10 in. in diameter, unfortunately the results were very erratic. Lanz Perlit iron was never meant to be used as a high-strength iron, but its shock resistance was good.

### Border-Line Processes

He was not particularly familiar with the Corsalli process, but as far as he knew it aimed at producing in the cupola a cast iron with low total carbon in the range of 1.0 to 1.4 per cent. The material is not really a true cast iron, but rather a border-line material, more related to cast steel. In the as-cast condition an average tensile strength had been quoted of 33 tons per sq. in. A much higher-strength low-carbon cast material was the Ford alloy cast crankshaft, but this also should not be classed as a cast iron. It was a cast crankshaft as opposed to a forged crankshaft.

He had heard of the Schüz process, but did not know very much concerning it. In addition to some of the irons he had already mentioned, 30 or 33 per cent. chromium irons were interesting. They were not used for their strength, but for their corrosion-resisting and wear-resisting properties.

### Composition and All-Pearlitic Structure

MR. VAN DER BEN said that, when viewing cast iron under the microscope, it was possible to obtain a pearlitic structure with combined carbon of roughly anything from 0.65 per cent. minimum. The effect of the phosphorus might have some bearing upon this. The effect of the addition of phosphorus to a pearlitic iron containing 0.65 per cent. of combined carbon would probably tend to throw the true structure of the iron more towards the higher combined carbon content. In other words, the addition of phosphorus might perhaps in some respects be similar to that obtained by a reduction of silicon, and in consequence the strength increased.

Lately his thoughts had been rather running in that channel; namely that the increase in phosphorus was really doing much the same thing as if an increase of strength was obtained by a reduction in silicon. In other words, phosphorus tended to annul the slight excess of pearlite which was obviously present, and yet did not show in the microstructure as free pearlite.

MR. MCRAE SMITH said this point had always puzzled investigators in the field of cast iron. As Mr. van der Ben had stated, it was possible to obtain a fully pearlitic cast iron with only about 0.65 per cent. combined carbon, while another one would approximate to saturation point.

MR. LAING said that the lecturer had referred to the height of the cupola as being from the top of the tuyeres to the charging door with 15 ft. maximum. He would suggest 18 ft. might be desirable in any size of cupola. There seemed to be a tendency to scaffolding with cupolas when taken beyond those heights. During the past week or two he had noticed an article in THE FOUNDRY TRADE JOURNAL recommending a lower height.

### Shape of Cupolas

MR. MCRAE SMITH said that perhaps he was somewhat of a faddist concerning high cupola stacks and with regard to obtaining all the advantages of pre-heating. By small cupolas he was speaking of 30 in., and then probably 12 ft. would be a better height than 15 ft. As far as scaffolding was concerned, he had not spent a great deal of time in considering the matter. If a furnace lining was kept definitely parallel and the charges were not too large, there should not be much trouble with scaffolding.

MR. LONGDEN inquired as to the incidence of blast pressure.

MR. MCRAE SMITH said that if there was to be a long pre-heating zone, or the length between the top of the tuyeres and the bottom of the cupola charging door was greater than normal, the fan would have to be satisfactory. A correct volume was maintained, and the blast pressure was suitably adjusted, because very well distributed blast pressure was necessary. There should be air distribution right into the centre, and yet there should not be such a low pressure that the air was only creeping round the walls.

He had not seen the report Mr. Laing mentioned concerning short cupolas, but he had often found in the light-castings trade in particular that cupolas which were installed perhaps a couple of years previously were very short. He thought it was a question of saving steel and bricks.

MR. J. JACKSON referred to the statement about keeping a cupola perfectly straight. Many cupolas were made perfectly parallel every day, the very large bellied portion in the melting zone being carefully patched. Yet by making such a curved section in the melting zone the cupola patching had been reduced very materially.

### Patching Problems

MR. MCRAE SMITH said the irons he had been speaking about were definitely high-strength irons, and for a few trades, particularly textile engineering, they were rarely necessary. What many people required was an accurately shaped casting, true to pattern, and of moderate strength. He disagreed with the idea that in making such high-strength irons an attempt was being made to turn out a poor substitute for steel. The irons had certain properties which were entirely different from those of steel.

In regard to the question of the patching and the keeping of the cupola lining parallel he was really thinking, when replying to Mr. Laing, of the old type of boshed cupola, which he did not like. Particularly when wishing to obtain accurate mixings, or even carefully controlled cast iron, there was likely to be trouble with this design of cupola shaft. As far as much patching was concerned, he would be rather inclined to think that the cupola was being severely over-blown. He appreciated the fact that the cupola was blown twice daily. A cupola should never be allowed to get into such a state. If it was necessary to put barrow-load after barrow-load of patching material into the cupola each morning, then there was something wrong with the cupola practice. It was not necessarily a question of eroding the lining; probably due to difficulties in drying and venting the large quantity of patching material, the lining would come down in any case. The patching in a cupola should be restricted and the blast conditions should be such that if a cupola was worn back 5 to 6 in. then it should be regarded as time to reline that part of the melting zone.

### Liquid Shrinkage

MR. W. HAYNES was particularly interested in the comments regarding feeding and running and getting equal thickness of metal in order to avoid liquid shrinkage. Assuming a casting of 8 tons, which varied in thickness from ¾ to 3 in., would Mr. McRae Smith be prepared to make a statement regarding the liquid shrinkage of such a casting with high-duty iron?

MR. MCRAE SMITH said that actually the freezing range of these high-strength irons was shorter than that of higher carbon irons, and shrinkage troubles were slightly increased in that respect. Correct carbon-silicon balance, however, allowed of good castability coupled with high strength. They were mostly low-phosphorus cast irons, however, and therefore there was not the shrinkage-porosity trouble experienced from a high phosphorus content. When lumpy castings were being produced it was necessary to have some sort of feeding head, of the correct shape and design. Mr. McRae Smith further illustrated the point by means of diagrammatic sketches on the blackboard with regard to shrinkage in Diesel liner practice and with regard to a plated flywheel made without rod feeding.

Continuing, Mr. McRae Smith thought that much might be done by a process of what he would term progressive solidification. This entailed much thought being given to design and distribution of runners, use of denseners, etc., with a view to superheating the mould

(*Continued on page* 227.)

# Rope Pulleys*

By JOHN R. WEBSTER

Since electric power transmission came into common use and motors became more reliable, the rope drive is not so commonly used as it once was, but there are still fair quantities of them in use, and as power transmission engineers, it is very seldom indeed that the author's firm is without rope pulleys of some sort in the foundry. Although the shape of the groove has changed considerably, yet, on the whole, sizes are smaller than they used to be. There are few castings currently made which involve so many different designs or lend themselves to so many different methods of moulding as the rope pulley. The reasons are possibly as varied as the designs themselves. It might be profitable, therefore, to consider what factors most profoundly influence design. As there is seldom more than one-off each pulley—unless in exceptional cases, where the pulley is part of a standard machine—a whole pattern is too expensive, and for large sizes, practically impossible. Therefore, the designer has usually considered the method most suitable for his foundry to produce. This feature probably explains how the many different types of arms, the varied methods of moulding grooves, and similar divergencies came into existence. The author's firm, after trying different designs, finally standardised on the design shown in Fig. 1. This particular pulley is 9 ft. 10 in. dia. over the rope pitch line; it has 17 grooves, and weighs 11,500 lbs. It was run with four 1¼ in. down-gates on the nave and the pouring time was 1.5 min. This pulley is a good example, though six arms per set are usually considered ample. In adopting this design, consideration was given first to appearance, aiming to produce a pulley as artistic as possible, whilst taking cognisance of the cost of production, including patternmaking. The latter cost is reduced to the minimum, by having the pattern parts, core boxes, sweeps and groove plates made to serve for a wide range of sizes. Moreover, due consideration was given to moulding, dressing and particularly machining costs, and the management was prepared to pay a little more in the foundry, if such costs could be recovered in the machine shop.

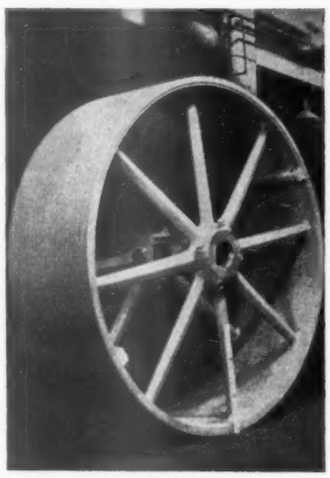

Fig. 1.—Design of Pulley discussed.

* Paper presented to the Scottish Branch of the Institute of British Foundrymen, Mr. A. L. Mortimer presiding.

### Working System

With this end in view, Mr. Hendry Fraser produced the system now in use in the foundry, and which has proved most satisfactory. Under the system all grooves are swept in loam, and necessarily stove dried. This reduces dressing costs, as there are no fins all over the face as there often is when the grooves are cored. It also reduces the machining allowance to a minimum, as there is no "siding" through cores being distorted by handling or core box rapping. Pulleys with a 12 in. face or less have the inside swept in green sand. Above this dimension, the inside or core is built and swept in loam. Small diameters up to about 4 ft. are built on a bottom-plate and stoved. Larger sizes are built in a pit and dried on the site.

### Tackle Used

Fig. 2 shows all the tackle set up ready to build the grooves. The spindle is 3 in. dia. and has a long taper in the footstep to ensure rigidity. The usual split collar is provided, on which rests an eccentric block with 1 in. eccentricity. The block is held in position with a pinching screw fronted with a gunmetal pad to keep the pressure from pitting the spindle. It has also a centre line on the top, through the eccentric. Over this, the sweep-arm works. The sweep for the grooves is cast iron, ½ in. in thickness. Down the length of the spindle is a line or member clearly defined approximately ½ in. wide and at least the same in depth. On the floor is a straight edge with a notch cut out to accommodate the spindle, and on the left can be seen a stake driven into the floor and properly plumbed to the vertical. A small straight edge is fixed to the bottom of the sweep with which the bed is swept, and after the usual preparation the cope ring is placed in position as shown in the illustration. These plates are necessarily thin, being only ¼ in. thick at the edge tapering back to about ⅞ in. to enable the moulder to get in the first groove. This carries all the building.

The back flange which is 5 in. by 3 in. is required to keep the mould rigid when stoving. In the foreground is the cake box. There are different thicknesses of these for the different sizes of ropes or pitch. Inside the box is a mild steel plate, with six holes punched out. Previous to starting a pulley, a labourer goes into the stove, the floor of which is plated, and makes as many cakes off this box as the moulder will require for building the pulley. Each cake has one of these plates bedded-in, so that the edge will come in line with the bottom of the groove. The cakes are 9 in. square, and the holes in the plate are for riveting on the loam. The labourer, when the cakes are dry, lifts them out of the stove, gives them a light rub with a card cloth, and sets them ready for the moulder who builds them as shown in Fig. 2, setting each cake with the sweep as he proceeds. After the moulder has completely built the half pulley, he then loams up and sweeps the grooves; loams up the ends and strikes them off with the straight edge, having a bearing on the spindle and also on the post already mentioned.

This only leaves the ends of the grooves to square off. For this purpose two short pieces of groove are provided. This half is now lifted away and placed on the stove carriage, and the other half plate is put down on the bed and the same process is repeated. Half-plates are only used for the larger sizes, as they can be more easily stoved. The moulder has now swept a half pulley, but he has done more than this, for he has swept a half pulley, plus ⅛ in. at each end to allow for machining and camber. This ⅛ in. is controlled by the straight edge—the straight edge being ⅛ in. back from the centre line of the pulley.

If this pulley had been about 7 ft or less in diameter the plate would have been whole instead of in halves. The procedure then would have been different after building the first half. Two print blocks for splitting cores 1¼ in. thick would have been provided, and would be placed against the struck face of the building. The eccentric block would have been turned over, and the building proceeded with as before. As there is one inch eccentricity on the block, the moulder is always sweeping 1 in. off the centre. This gives a 2 in. gap between the two halves of the mould, and is used for ¼ in. machining each side on this size of pulley and ⅛ in. for camber, which is insufficient. This finishes the building of the grooves, and as they are now stoved it seems worth while to examine the building of the inside or core.

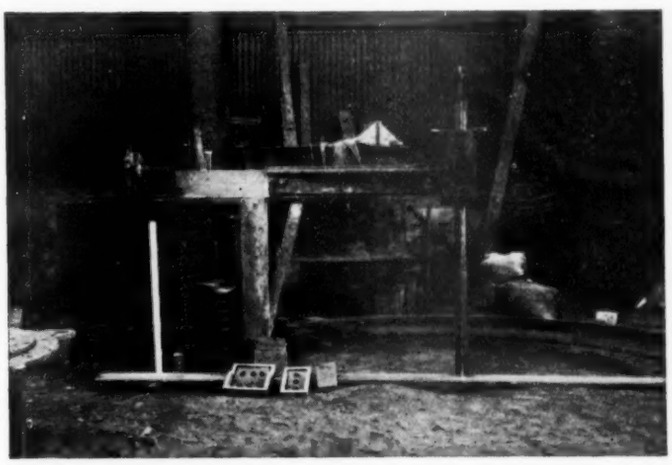

Fig. 2.—Tackle for Building the Grooves.

### Core Making

It is regretted that Fig. 3 does not show more of the operation. It would have been better if it could have shown the inside or core of the pulley half built with the arm cores set in position, but an attempt at rectification will be made by description. There can be seen at the back of the spindle (Fig. 3) the arm core box. It has a metal head, machined at the joints at the correct angle and flanged at the bottom to allow of the bolting on of a wood bottom. This is a standard depth, but the depth or thickness of the core is controlled by the length of nave

required. It should be noted that this box has a second bottom to make it of the necessary depth. The arm is loose, and in the centre of the bed, the section of the nave where it fits into the mitre end and the end, is held in position by the blocks fixed to the side. The arm is tapered and dowelled into the fillet on the back. After the arm is rammed up in dry sand and turned over on a plate, the back, with the fillet, comes away. The arm is then drawn out, and the core is ready for stoving.

After drying, it is blackened and is then ready for building in. The other box shown is for making the distance piece between the naves of the two sets of arms. This carries a print for the core through the nave, and also a tee-section-piece, about 2 in. by 2 in. by 1 in., which joins the two naves together. This keeps "spring" from affecting the arms, and as the pulleys are run off the nave the iron flows through these and fills the bottom part of the mould. The two long pieces shown in Fig. 3 are the patterns for the bolt lugs carrying a print for the splitting core. The sweep for the inside of pulley is in position, and from this view can be seen the arrangement for setting.

The arm is machined at the neck to a given size from the spindle centre. It is really machined all along the face and the top edge. On this edge, a plate is fixed projecting about ¼ in. over the face, and thus making a flange. To set the sweep, it is put in the arm, close up to the shoulder and against the flange along the top and bolted up; a little "plumbing" to guard against any droop is all that is required. The patternshop foreman is responsible for sizes, and there are no size sticks used. The crosspiece, on the bottom of the sweep, is for sweeping the bearing for the first set of arm cores. There is a permanent plate in the bottom of the pit. This is cleared and the sweep set for height. A single-brick bearing is built round the spindle wide enough to support the tapered end of the arm core, and another at the centre of the arm and at the rim. On these, when laid down, a facing of loam is swept. Ascertaining that the eccentric is sound, the process is repeated for the other half, whilst leaving gaps at the sides to accommodate the bolt lugs.

The mould is now ready to receive the arm cores. The straight edge is again placed in position, using the centre line connecting with the line on the spindle, and weighted down. A templet, the size of the half nave, with a gap to fit the spindle, is placed against the straight edge. The cores are set to this, first the outside ones, the straight edge and templet giving the angle for the arm. Then the other cores are fitted in and equally spaced. When this is done, the straight edge is lifted away and the arms on the other half are set. The only difference here is that, instead of the straight edge, there is a 1½ in. block to place against the arm already set. The next arm core is placed against this, the nave templet getting the proper angle as before. The block is then withdrawn, and leaves the print for the nave splitting-core.

The crosspiece on the bottom is unscrewed and lifted to the next position, forming the bearing for the next set of arm cores, and the bottom nave is now properly finished. The two distance-piece cores being set, they form a cover core for the bottom nave, and the bottom of the top one. The first one is set with the straight edge and a templet for the core print; for the other side, the 1½ in. block or print is again used. The moulder now builds in between the arm cores with brick to form the inside of the pulley. Sometimes he builds brick round the outside of the distance-piece, depending upon how much bearing is available. These have to be well secured, as this is the only possible place for iron to escape from the mould. When the building comes up to the crosspiece, a single brick bearing is brought up from the centre of the arm core, carrying the exact width of the core, and supporting the centre of the core on top. This bearing is then loamed and swept, and the crosspiece is taken off. The next set of cores is then placed in the same manner as before, and the building is carried to the top. Then the bolt lugs are set in position, again using the straight edge and a plumb-bob. These are built in. The bearing for the cope is then set, after which the face is loamed up and swept. The edge at the top is sharpened up and the bolt lugs drawn out, and the job is ready for drying. To effect this, it is covered with plates, and fires are lit at four or more places according to the size of the pulley. The fire travels round slowly, and is so stoked that it is just burned out by morning. The heat is never allowed to be too strong, and the mould is dry and in a suitable condition for blacking. After blacking and finishing it is given another light firing, and the mould is as shown in the background of Fig. 3. During this time, the grooves have been finished, stoved, blackened, and are ready for assembly, as are also a cover plate for the rim; a dry-sand top-part to cover the nave, with the necessary runners, and the cores for the split and bore.

In Fig. 4 is shown the space in the grooves for the splitting core. The part shown is lowered into the inner part of the mould, set properly, and gauged all round for metal thickness. The splitting cores for the bolt lugs are put in from the outside and the back is rubbed up with good stiff loam. The cover plate is placed on the rim; the splitting cores through the nave slipped in and the ends secured; the parts of the core placed in position; the dry sand cover or sometimes a loam plate put in place over the nave, and the assembly is complete.

"Cribs" put round the outside are shown at the back of the mould in Fig. 5; actually they are not deep enough for the pulley illustrated. A mild steel ring is placed round the bottom and rammed. The crib plates are then put in position and well rammed to the top of the mould. The inside, which is open between the arm cores, is filled in with sand, which is merely tamped in with a touch round the sides or under the cores with a shovel shank. The head box is put on and the head made up carefully with a skimmer core bedded in about 8 in. or 9 in. from the downgates. The whole is then weighed down, using weights in preference to binders.

The foregoing is a description of a system of moulding rope pulleys, and if one considers that all the pattern tackle is adaptable for many other sizes; that the machining is cut down to a minimum as the grooves are clean and true; that the dressing costs are negligible, it is obviously a worth while process. Though the moulding operations may seem rather involved, they are not really so, and it is surprising how expert and fast a good moulder soon becomes on this job.

Fig. 3.—Some of the Core-making Tackle Used.

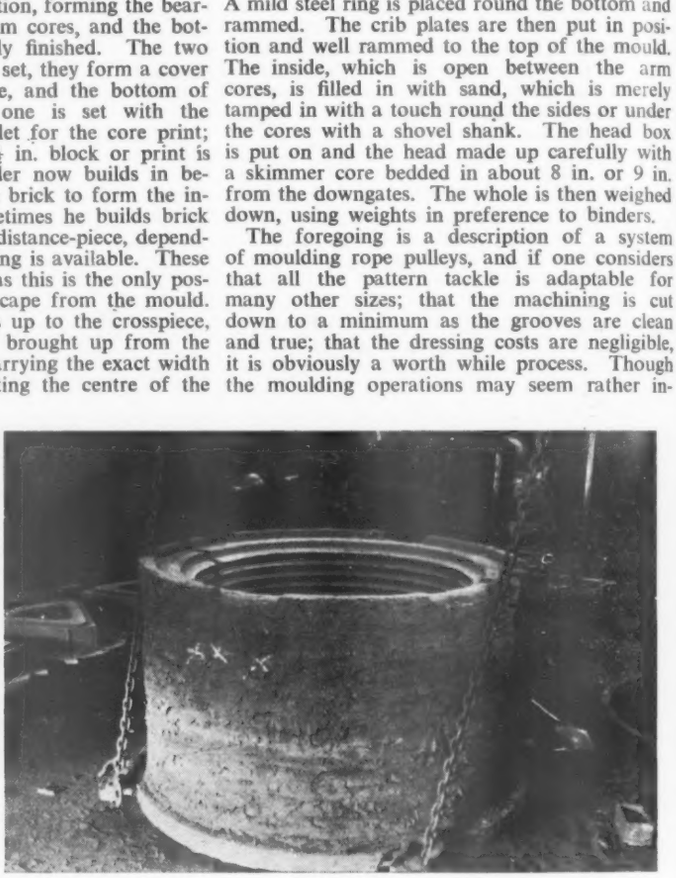

Fig. 4.—Showing Provision made for Splitting Cores.

### Inherent Difficulties

There are obviously some difficulties in the moulding of rope pulleys. The usual practice until some years ago was to mould the pulley as near the size as possible. It was marked off and machined to the given size, due regard being given to strength or rather metal thickness at the bottom of the grooves, for ¼ in. or ⅛ths of an inch on the diameter of a 10-ft. pulley was not considered a fault.

New conditions arose when an order for a range of pulleys showed sizes given to two places of decimal such as 59.58 in., 118.38 in., and 63.36 in. over the rope pitch dias. These are three of the actual sizes, and the inspection was to be very exacting. The first pulley of this series, shown in Fig. 1, sent to the machine shop brought back a report that it would not machine up to size. The desired size was 59.58 in. dia. and was to be over size in inside diameter by ⅛ in., but after marking off it was machined to the specified dimensions. The sweeps were checked and found to be correct to contraction rule of $\frac{1}{10}$ in. per ft. Test bars showed that the iron had contracted normally. It is thus apparent that the main difficulty to be overcome in pulley manufacture is that of contraction.

### Contraction Problems

The conclusion reached was that the casting did not contract according to rule, and as the foundry was then making another pulley exactly the same size, it was decided to take $\frac{1}{8}$ in. off the sweeps, which would involve $\frac{1}{4}$ in. off the diameters, thus reducing the contraction allowance by 50 per cent. The inspector's report stated pulley was concentric internally but still $\frac{1}{8}$ in. too large. It was too early at this stage to have a definite opinion, but one could assume that pulleys of this type cast in loam contracted less than half the normal allowance of $\frac{1}{10}$ in. per ft. The next pulley, 118.38 in. R.P. dia. by 12 grooves, was very close to the size of the one illustrated in Fig. 1. This was the second one cast, and was being moulded at the same time as the first. Therefore no change had been made, and it was produced under normal practice, with the usual contraction allowance. The sizes required were 119.63 in. dia. over the flanges, and 114.214 in. inside diameter. The casting measured inside the rim from the centre of the nave through the centre arm 114.75 in., that is 0.536 in. too large. Across the split it measured 115 in.—an error of 0.786 in. The author has found an error of 0.536 in. in actual diameters, but a greater difference through split. There the error is 0.786 in., which would mean that if this pulley was machined to the sizes demanded, the metal at the bottom of the grooves would be too thin by $\frac{1}{8}$ in. at the split to $\frac{1}{4}$ in. at the centre arm. This pulley was not accepted by the machine shop, and the sizes again show that pulleys cast with a loam centre contract only by half the usual allowance.

The difference in size through the split was a graver problem. Here the contraction had been only about 20 per cent. of the normal allowance. This condition, it was judged, arose through the contraction operating along the periphery until it was stopped by the strain on the side arms. This was a known but only dimly recognised fault in pulley manufacture, and had been until now counteracted only by bringing out the rim beyond the centre line of the nave, to allow for what was loosely termed "camber," but something more was now called for.

On the next pulley of this same size but carrying 14 grooves, which it was anticipated would contract along the same lines as the last one, it was determined to sweep $\frac{1}{4}$ in. smaller in diameter through the lugs than through the centre rim of the arm. This was the only alteration made, and though it left room for a fault it was such that there would be material enough for correction in the machining. The sizes required were 119.6 in. outside diameter and 114.214 in. inside. The inspector's report stated that the outside diameter was 120 in. and the inside 114.214 in. This was correct, but as the contraction allowance had not been altered, the centre had to be put forward, leaving too much to machine off the joint and the slight thinning of the bolt lugs. The next step was to reduce the contraction allowance and to reduce slightly the amount taken off the diameter. Careful records were kept over a long range of pulleys until the management was able to gather sufficient data to enable them to issue an instruction sheet stating the contraction allowance and the amount the sweep was to be drawn in for different sizes of pulleys. This has now become a matter of routine. The contraction allowance for pulleys made in loam is $\frac{1}{20}$ in. per ft. Pulleys with the inside of green sand the usual $\frac{1}{10}$ in. per ft. From 5 ft. to 7 ft. dia. inclusive, the amount taken off the diameter through the split $\frac{1}{4}$ in., which means the sweep is drawn in $\frac{1}{8}$ in. (see Fig. 2). From 8 ft. to 10 ft. the sweep is drawn in $\frac{1}{4}$ in., making $\frac{1}{2}$ in. difference in the second diameter. To draw in the sweep, the eccentric block is turned off the centre line and the sweep worked from the outside to the centre. The action is then reversed, and the other side swept from outside to centre. Thus $\frac{1}{8}$ in. off the centre line draws in the sweep $\frac{1}{4}$ in. As the top of the block is lined off in eighths on each side of the centre line, the moulder has no difficulty in bringing the sweep to any desired position. These corrections only apply to pulleys with six arms per set.

On the range of pulleys that have been cited, the analysis throughout was: T.C, 3.3; Si, 2.0; Mn, 0.7, and P, 0.54 per cent., yielding tensile tests of the order of 12 tons per sq. in. The one shown in Fig. 1 gave T.C, 3.26; Si, 1.85; Mn, 0.72, and P, 0.45 per cent., but the test bar gave a tensile of 15.5 tons. This would be an argument in favour of making these pulleys of still lighter section. The author gratefully acknowledges the help given by his directors and colleagues in the preparation of this Paper.

FIG. 5.—MOULD READY FOR PLATES.

FIG. 6.—SHOWING FINISHING OPERATIONS.

### Cast-iron Pipe Lining

The application of an undercoating of light water-gas tar containing finely ground slate flour in suspension is claimed to provide a better lining for cast-iron pipes, to give a stronger base for a tar coating and to avoid pinholes. The procedure, which has been developed in America, consists in applying the mixture to the pipe, which is then heated to a high temperature while being rotated. The tar volatiles are expelled, leaving a tough, infusible, insoluble and firmly bonded base of carbon and slate flour adhering to the surface of the pipe. This reticulated structure does not itself provide a protection against corrosion, but will hold tenaciously a second coating of tar applied by ordinary immersion. Total thickness of the two coats is stated to be between 4 and 5 mils.

## Melting and Casting Problems

(*Continued from page* 224.)

faces in thin parts and selectively cooling others quickly.

MR. A. HOPWOOD inquired what would be the effect on the structure of a quick cooling of any section in relation to the rest of the casting owing to the use of any material which would act as a densener or hasten the transmission of heat from one part to another. Was the acicular structure destroyed by the use of denseners?

MR. MCRAE SMITH was unable to say; he had not densened any casting with acicular structure. Nevertheless he did not think it would be destroyed unless the densener was too heavy. The real answer to the question was that denseners must be very carefully designed. The dimensions and mass of the densener must be such that there was no possibility of experiencing more than an equalisation of cooling. After all, it was simply a method of quick conduction of heat, which would give the same cooling rate on a heavy section compared with the lighter sections, which cooled off and consequently solidified more quickly.

### Vote of Thanks

MR. E. LONGDEN, in proposing a hearty vote of thanks to Mr. McRae Smith for his extremely interesting and instructive Paper, said that an enormous amount of material had been dealt with, the implications of which could not be fully absorbed during the hearing of the lecture. Mr. McRae Smith was certainly doing much excellent work during the war period.

MR. J. LAING (who has since died) seconded the vote of thanks, saying that he had been associated with Mr. McRae Smith many years ago, and therefore had some first-hand knowledge of his capabilities. The author had delivered a very practical, though somewhat academic Paper, and no doubt the skilled moulder would now better appreciate the metallurgical side of the high-strength irons.

The vote of thanks was carried unanimously.

MR. MCRAE SMITH, responding, said that the provision of steel scrap presented a certain difficulty, and he quite appreciated how foundrymen would feel about it. Actually, as he was going about the country on his particular present-day job, he found that as far as some localities were concerned the foundries had plenty of suitable steel scrap on hand, while others had difficulty in obtaining supplies.

## Relative Scrap and Pig-Iron In Open-Hearth Steel

The subjoined table compiled by the "Iron Age" from official returns shows the changes in the relative scrap and pig-iron consumption in the production of open-hearth steel in the period 1935 to 1940 in the United States, all per ton of open-hearth steel ingots made.

| Year. | Pig iron, tons. | Scrap, tons. | Ratio: pig-iron to scrap. |
|---|---|---|---|
| 1935 .. | 0.45 | 0.62 | 0.73 |
| 1936 .. | 0.45 | 0.62 | 0.74 |
| 1937 .. | 0.54 | 0.57 | 0.95 |
| 1938 .. | 0.53 | 0.56 | 0.95 |
| 1939 .. | 0.56 | 0.54 | 1.04 |
| 1940 est. .. | 0.58 | 0.53 | 1.09 |

### Steel Castings Manufacture in Queensland

Queensland Electric Steel, Limited, has been registered in Brisbane, and works have been erected at Maarooka, where the concern is to produce electric steel castings from carbon, manganese, chrome and nickel steels, reports "Industrial Australian and Mining Standard."

# Molybdenum in Enamels

## ADHERENCE PRODUCED WITH MOLYBDENUM COMPOUNDS*

By KARL KAUTZ

### Introduction

Molybdenum compounds are used to-day in very limited quantities in the ceramic industry. Very little is known about their ceramic behaviour, and only a few published articles mentioning molybdenum have been found. Housley and King[1] smelted 7.5 per cent. antimony trioxide and 1.5 per cent. molybdenum trioxide in a typical colourless enamel base and obtained evidence of enamel adherence to sheet steel. Amberg, Prior and Richmond[2] found that a deposit of a hydrated suboxide of molybdenum formed by electrodeposition on the surface of sheet steel caused a white enamel to adhere tenaciously.

The experiments of Housley and King seemed to offer commercial possibilities for producing light-coloured ground coats. However, a thorough check of this enamel, both in laboratory and plant, failed to show satisfactory adherence to sheet steel. Changing the enamel formula and smelting in various amounts of $Sb_2O_3$ and $MoO_3$ still failed to produce satisfactory enamel adherence. Chemical analyses showed that when $MoO_3$ was smelted in an enamel only a portion remained because $MoO_3$ is readily volatile at smelting temperatures. The $MoO_3$ remaining did not function as an adherence-promoting agent.

A clear frit was milled with 3 per cent. $Sb_2O_3$ and 1.5 per cent. $MoO_3$. This enamel, when applied in the usual manner, gave excellent adherence to sheet steel. The enamel made in this manner, although giving excellent adherence, caused severe tearing or crawling when fired. It showed, however, that $MoO_3$ in conjunction with $Sb_2O_3$ could be used to promote adherence of ground coats to steel.

### Properties of Molybdenum and Some of Its Compounds

*Molybdenum* is a very hard, silver-white metal. It is oxidised easily to $MoO_3$ in air at elevated temperatures. Its melting point is extremely high (2,600 deg. C.), and it makes excellent electrical resistors for high-temperature work when protected from oxidation. Its principal use as a metal is in the making of filaments, screens and grids for radio

*Molybdenum trioxide* ($MoO_3$) is the stable high-temperature oxide. It is formed when molybdenite ($MoS_2$), metallic molybdenum and other compounds are heated in excess air. When pure, it forms yellowish-white rhombic crystals having a melting point of 794 deg. C. Its vapour pressure is slight at 593 deg. C.; at 704 deg. C. it is 0.30 mm. Hg.; at the melting point it is 10 mm. Hg, and at 1,154 deg. C. it is 760 mm. Hg. Thus, it sublimes to some extent even before it melts. The trioxide is a good oxidising agent, readily furnishing oxygen in the presence of oxidisable substances, both in wet and thermal reactions. Like $SO_3$, it unites directly with alkalis, alkaline earths, and other metallic oxides to form molybdates. It is one of those chemical compounds which forms a great number of complex compounds with other elements and compounds. $MoO_3$ is soluble in water. At room temperature 0.1 grm. will dissolve in 100 ml. of water and 2.0 grms. in the same quantity of boiling water.

*Molybdenum dioxide* ($MoO_2$). When $MoO_3$ is heated in a current of a reducing gas, or in contact with any solid reducing agent at about 760 deg. C., it is reduced to brown molybdenum dioxide. At lower temperatures purple or violet coloured oxides are formed, which analyses indicate are probably $MoO_2$, $2MoO_2$ or $Mo_3O_8$. Molybdenum dioxide is insoluble in water, has a high melting point, and when heated in air (even below a red heat) is oxidised readily to $MoO_3$.

*Molybdates.* $MoO_3$ is acidic in character. It combines with most bases or basic oxides directly either by wet or thermal reactions. It does not combine directly with $SiO_2$, but does form complex hydrated molybdo-silicates. Like the analogous sulphates, the most common insoluble molybdates are lead and barium. Calcium molybdate is only slightly soluble in water. The normal molybdates of the alkalis, alkaline earths, lead and zinc have high melting points, and are all white compounds.

### Problems arising from the Use of Molybdenum Compounds in Enamels

$MoO_3$ smelted in an enamel does not function as an adherence-promoting agent. When the $MoO_3$ is milled into the frit along with $Sb_2O_3$ it does function to promote adherence. However, because $MoO_3$ is soluble in the mill liquor, it causes cracking of the enamel coat during drying and, thus, crawling or tearing during firing. Molybdenum trioxide unites with water to form molybdic acid, $H_2MoO_4$, which compound shrinks when it is dehydrated. In an applied enamel coat, this shrinkage of the molybdic acid present causes cracks to form in the drying coat, often accompanied by peeling. Soluble compounds such as sodium molybdate likewise cannot be used in milled enamels, because they cause scumming and tearing of the enamel coating.

The problem then became one of finding an insoluble form of molybdenum which will still function as an adherence-promoting agent in the firing of ground coats. Many different kinds of compounds, both simple and complex, were made and tried experimentally in clear ground coats. The compounds, or mixtures, described in the following paragraphs are the best developed up to the present time, but may not be the best ultimately possible.

### Molybdenum Compounds Promoting Adherence when Used as Mill Additions

*Molybdenum Trioxide* ($MoO_3$).—A mixture of $Sb_2O_3$ and $MoO_3$ milled into a clear enamel base produced excellent adherence, but only within certain limits. A study was made varying $Sb_2O_3$ from 0 to 4 per cent. and $MoO_3$ from 0 to 4 per cent. It was found that poor adherence was obtained when the $MoO_3$ was 3 per cent. and 4 per cent. regardless of $Sb_2O_3$ content. Zero $MoO_3$ with 1 to 4 per cent. $Sb_2O_3$ gave only weak adherence and zero $Sb_2O_3$ with 1 to 4 per cent. $MoO_3$ gave poor adherence. One per cent. and 2 per cent. $MoO_3$ gave the best adherence with the $Sb_2O_3$ ranging from 1 to 4 per cent. The best adherence always seemed to be associated with a ratio of two parts by weight $Sb_2O_3$ to one part by weight of $MoO_3$. This led to the belief that the molecular proportion $Sb_2O_3 : MoO_3$ (292 : 144) might possibly produce the best adherence. If this be true, then the compound $Sb_2O_3 \cdot MoO_3$ should promote excellent adherence, and experiments with this compound to be described confirm this.

*Antimonyl Molybdate* ($Sb_2O_3 \cdot MoO_3$—also may be written $(SbO)_2MoO_4$).—This compound was made by heating an intimate mixture of $Sb_2O_3$ and $MoO_3$ in molecular proportions to 815 deg. C. in the absence of air. The melting point of this compound is between 482 and 510 deg. C. Upon cooling, it forms a yellow-brown crystalline mass which becomes brownish-yellow or ochre-coloured upon fine grinding. Additions of 3 or 4 per cent. of this compound produced excellent adherence when milled with a clear enamel base. The two most serious objections to its use are the brownish-yellow colour imparted to the enamel and a slight tendency to crawl.

*Barium Antimony Molybdates.*—In order to render the antimony and molybdenum oxides even more insoluble, barium oxide was introduced in the following molecular ratios:—(1) $2BaO \cdot Sb_2O_3 \cdot MoO_3$; (2) $BaO \cdot Sb_2O_3 \cdot MoO_3$; and (3) $BaO \cdot Sb_2O_3 \cdot 2MoO_3$.

The first calcine, which possibly may be the double compound, $Ba(SbO_3) \cdot BaMoO_4$, is pure white. This compound or calcine, gives excellent adherence and also opacity when milled into a clear enamel base. Further experimental work is necessary, however, to make this compound commercially successful because of the erratic behaviour of some of the batches. Some calcines worked splendidly, others the reverse. It is believed that this calcine must be controlled within a narrow range of time, temperature and degree of oxidation so as to produce the desired results.

The second calcine, $BaO \cdot Sb_2O_3 \cdot MoO_3$, has a brownish-yellow colour and is produced only when calcined in the absence of air. It imparts a slight yellowish colour to the enamel and causes slight tearing. The third calcine, $BaO \cdot Sb_2O_3 \cdot 2MoO_3$, has a light brown colour, and is produced by calcining in the absence of air. It imparts a yellow-brown colour to the enamel and causes severe crawling.

*Calcium Antimony Molybdate* ($2CaO \cdot Sb_2O_3 \cdot MoO_3$), corresponding to the barium compound, was prepared by calcining the proper molecular proportions. This calcine has a yellowish-brown colour, and produces poor adherence and severe crawling.

*The compounds,* calcium molybdate ($CaO \cdot MoO_3$), barium molybdate ($BaO \cdot MoO_3$), lead molybdate ($PbO \cdot MoO_3$), stannous molybdate ($SnO \cdot MoO_3$) and ferrous molybdate ($FeO \cdot MoO_3$) did not work successfully alone. With the addition of $Sb_2O_3$ or with the antimoniates of calcium or barium fair adherence was obtained with some of these molybdates.

*Molybdenum Blue* is the name given to the suboxides obtained by reducing $MoO_3$ when suspended in water. The composition is variable and may be represented by the formula

* Paper presented to the American Ceramic Society and made available through the courtesy of the Climax Molybdenum Company of Europe, Limited.

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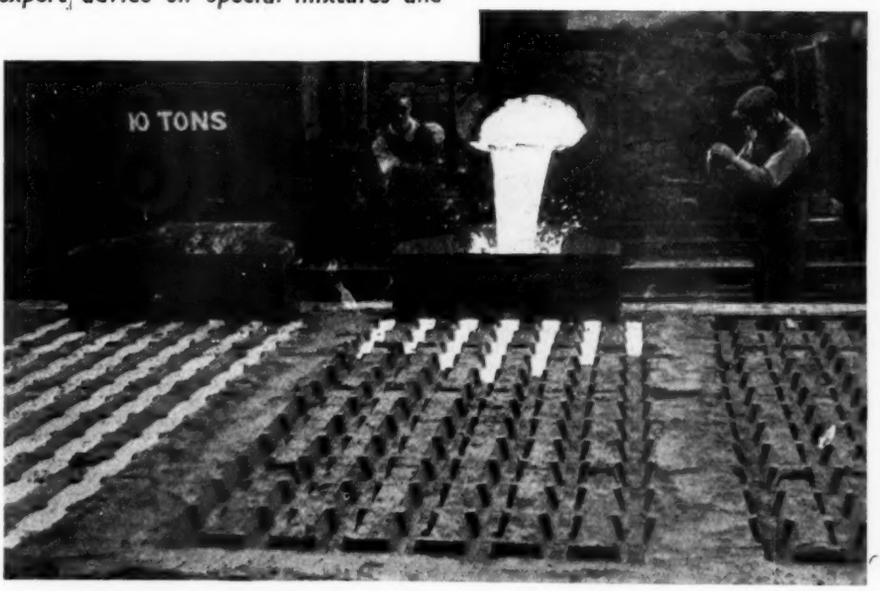


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$xMoO_2$-$yMoO_3$-$zH_2O$. It forms deep-blue colloidal suspensions in water with properties similar to a dyestuff. Milled with a clear frit and $Sb_2O_3$, it gives excellent adherence, but tends to crawl severely.

*Molybdenum Dioxide* ($MoO_2$) is produced when $MoO_3$ is heated with a reducing agent, either solid or gaseous. When milled with $Sb_2O_3$ in a clear frit, it produces excellent adherence. Unlike $MoO_3$, it produces no crawling, tearing or peeling in the enamel. This is due to it being insoluble in the mill liquor. Excellent working properties in the slip as well as excellent adherence on fired specimens result when $MoO_3$ is used in amounts of 0.5 to 2 per cent. and $Sb_2O_3$ in amounts of 0.5 to 3 per cent. A proportion of 2.25 per cent. $Sb_2O_3$ and 1.25 per cent. $MoO_2$ was used successfully in many enamels. The theoretical proportions 2.92 per cent. $Sb_2O_3$ and 1.28 per cent. $MoO_2$ give excellent adherence, but are sometimes accompanied by "antimony blisters," which are eliminated if an excess of $MoO_2$ is used. The proper amounts to use will depend upon the nature of the heat-treatment to be given the enamel.

### Types of Enamels Work Successfully with Antimony-Molybdenum Oxide Combinations

The most successful enamel batches have been found to be almost identical with those developed for the cobalt-type enamels. A typical enamel of this type smelted without the additions of cobalt, nickel and manganese oxides will produce excellent adherence when milled with $Sb_2O_3$ and $MoO_2$. When using $Sb_2O_3$ and $MoO_2$ as the adherence-promoting agents an enamel high in zinc oxide generally produces poor adherence. $P_2O_5$ introduced as calcium phosphate or bone-ash causes blistering. High fluorine, introduced as cryolite, also causes blistering. Fluorine, not over 0.3 molecular equivalent, may be introduced as fluorite without difficulty.

Adherence is adversely affected by most opacifiers. Antimony oxide smelted into the enamel batch causes a decrease in adherence, although possibly not enough to cause serious commercial difficulties. Milled-in opacifiers, such as the commercial zirconium opacifiers, also cause a slight decrease in adherence. From the data to be presented it can be seen that enamels of the proper composition may be compounded for any firing range between 787 and 870 deg. C., and good adherence obtained by milling in the proper amounts of $Sb_2O_3$ and $MoO_2$.

### Factors Affecting Adhesion of Vitreous Enamels to Sheet Steel

(*a*) *Physical Condition of the Metal Surface.*—The prime requisite for the adherence of any vitreous enamel is an iron surface free from grease, oil or dirt. The degree of pickling or etching of the surface depends upon the oxidising conditions encountered in the firing process. In laboratory furnaces with a slow comeback, deep etching is necessary to bring about maximum adherence. In industrial furnaces, both box and continuous, where severe oxidising conditions and rapid heat transfer occur, lighter pickling is sufficient for good adherence.

(*b*) *Enamel Composition and Fluidity.*—It is generally understood that a successful ground coat must have good fluidity so that the gas generated by reactions occurring at the iron surface during the firing can escape without permitting excessive oxidation of the iron base. For this reason great care must be exercised when adding heavy opacifiers to ground coats. The composition of the ground coat must be such that iron oxides are easily absorbed.

(*c*) *Oxygen-Carrying Ability of the Adherence-Promoting Agents.*—The third factor which influences the adhesion of enamels to iron is the presence of oxygen-carrying agents in the enamel. Cobalt and nickel are understood to function because they are able to absorb oxygen from the air and give it up to the iron base. It is believed that molybdenum oxides in combination with antimony trioxide also do this.

### Probable Explanation of Function of Antimony and Molybdenum Oxides in Enamels

It has been stated that $MoO_3$ smelted in enamels does not produce adherence. Because antimonyl molybdate ($Sb_2O_3 \cdot MoO_3$) as well as mixtures of $Sb_2O_3$ and $MoO_3$ and mixtures of $Sb_2O_3$ and $MoO_2$ function as mill additions to produce adherence, it is believed that the compound $Sb_2O_3 \cdot MoO_3$, and not a glass solution of these compounds, is the oxygen carrier.

The compound $Sb_2O_3 \cdot MoO_3$ forms readily when a mixture of $Sb_2O_3$ and $MoO_3$ is heated. It is a compound of low fusibility and easily oxidises iron. Antimony trioxide does not dissolve readily in enamels, but it combines with $MoO_3$ below the softening point of the frit. This is probably the reason $MoO_3$ can function as an oxygen carrier only in the presence of $Sb_2O_3$. When a light-coloured ground coat, containing milled-in $Sb_2O_3$ and $MoO_2$, is heated in contact with iron, the following reactions might occur:—

(1) $2Sb_2O_3 + 2MoO_2 + O_2 \rightarrow 2Sb_2O_3 \cdot MoO_3$

(2) $Sb_2O_3 \cdot MoO_3 + Fe \rightarrow FeO + Sb_2O_3 + MoO_2$

In the early stages of firing, before the enamel fuses, $MoO_2$ absorbs oxygen to form $MoO_3$, which combines with $Sb_2O_3$ to form antimony molybdate, $Sb_2O_3 \cdot MoO_3$. This has a twofold purpose: by rapidly absorbing atmospheric oxygen, excessive primary oxidation of the iron base may be prevented; and by forming the very fusible antimonyl molybdate, the unfused coating tends to become vitrified, thereby diminishing further primary oxidation of the iron base.

The iron base is oxidised by the liberation of some of the available oxygen in the antimony molybdate. The antimony molybdate then is regenerated by oxygen carried into the glass from the furnace atmosphere. This reaction is probably cyclical throughout the firing period. It has been observed that oxidation of the iron base takes place continuously under the fused glassy coating, because these enamels, with prolonged heat-treatment, tend to become saturated with iron oxides, that is, become black or "burned off."

### Typical Enamels and Mill Batches

For ground coats maturing at 860 to 870 deg. C. a number of compositions work successfully. In fact, almost any cobalt enamel batch without the colouring oxides can be used. A typical enamel in this range is:—

Enamel No. 1.
*Empirical Molecular Formula.*

$0.15\ K_2O$, $0.60\ Na_2O$, $0.25\ CaO$ } $0.15\ Al_2O_3$ { $2.0\ SiO_2$, $0.6\ B_2O_3$, $0.25\ F_2$

*Smelter Batch, per cent.*

| | |
|---|---|
| Borax | 35.5 |
| Feldspar | 26.0 |
| Quartz | 20.5 |
| Soda ash | 6.6 |
| Soda nitre | 5.3 |
| Fluorite | 6.1 |

The above enamel with antimony oxide smelted-in the batch is:—

Enamel No. 2.
*Empirical Molecular Formula.*

$0.15\ K_2O$, $0.60\ Na_2O$, $0.25\ CaO$ } $0.15\ Al_2O_3$ { $2.00\ SiO_2$, $0.60\ B_2O_3$, $0.25\ F_2$, $0.04\ Sb_2O_5$

*Smelter Batch, per cent.*

| | |
|---|---|
| Borax | 34.40 |
| Feldspar | 25.00 |
| Quartz | 19.80 |
| Soda ash | 6.40 |
| Soda nitre | 5.10 |
| Fluorite | 5.80 |
| Antimony trioxide | 3.50 |

A soft ground coat, which may be fired at 815 deg. C., or lower, is:—

Enamel No. 3.
*Empirical Molecular Formula.*

$0.10\ K_2O$, $0.60\ Na_2O$, $0.20\ CaO$, $0.10\ BaO$ } $0.10\ Al_2O_3$ { $1.50\ SiO_2$, $0.80\ B_2O_3$, $0.20\ F_2$

*Smelter Batch, per cent.*

| | |
|---|---|
| Borax | 47.40 |
| Feldspar | 17.30 |
| Quartz | 16.80 |
| Soda ash | 4.90 |
| Soda nitre | 2.70 |
| Barium carbonate | 6.10 |
| Fluorite | 4.80 |

Also at 715 deg. C., or lower, the same enamel may contain a small amount of antimony trioxide smelted-in. This is:—

Enamel No. 4.
*Empirical Molecular Formula.*

$0.10\ K_2O$, $0.60\ Na_2O$, $0.20\ CaO$, $0.10\ BaO$ } $0.10\ Al_2O_3$ { $1.50\ SiO_2$, $0.80\ B_2O_3$, $0.20\ F_2$, $0.04\ Sb_2O_5$

*Smelter Batch, per cent.*

| | |
|---|---|
| Borax | 45.80 |
| Feldspar | 16.70 |
| Quartz | 16.20 |
| Soda ash | 4.70 |
| Soda nitre | 2.50 |
| Barium carbonate | 5.90 |
| Fluorite | 4.70 |
| Antimony trioxide | 3.50 |

These frits are milled in the usual manner to about 8 grms. on 200 mesh for a 100-grm. sample. A typical mill batch, expressed as lbs., is:—Frit, 1,000; Vallendar clay, 70; borax, 5; and water, 550; to which the following amounts of adherence-promoting agents are added before milling: $Sb_2O_3$, 22.5 (15 to 30); and $MoO_2$, 12.5 (7.50 to 20).

There is a considerable range in the amounts and proportions of $Sb_2O_3$ and $MoO_2$ which produce good adherence, depending upon the nature of the iron surface, the thickness of the coating and furnace conditions. The proper additions for any particular set of conditions must be determined experimentally.

Although it is not necessary, the $Sb_2O_3$ and $MoO_2$ may be wet-milled together and then dried before adding to the mill batch. This appears to improve the gloss and texture of the enamel and to give greater uniformity. A mixture of 65 parts $Sb_2O_3$ and 35 parts $MoO_2$ prepared in this manner gave good results when used in amounts of 3 to 4 per cent. of the frit weight.

In place of $Sb_2O_3$ and $MoO_2$, antimonyl molybdate or barium antimony molybdate, prepared by methods already described, may be used. Suggested additions of these compounds are:—$Sb_2O_3 \cdot MoO_3$, 2.5 to 4.0 per cent.; and $2BaO \cdot Sb_2O_5 \cdot MoO_3$, 5.0 to 8.0 per cent.

### Discussion

The idea of adding the oxygen carriers or adherence-promoting agents as mill additions seems to be a definite departure from customary enamelling practice. Numerous laboratory tests and several plant tests have demonstrated that the antimony-molybdenum combinations give adherence comparable with typical cobalt ground coats. Mill additions of adherence-promoting agents permit finer adjustments of the ground coat under operating conditions. Not only can two or more frits be blended at the mill, but also the proportions and amounts of $Sb_2O_3$ and $MoO_2$ may be varied. Also, certain opacifiers may be added at the mill, if desired, although the heavy opacifiers generally tend to decrease adherence. From tests conducted so far zirconium opacifiers seem to give less trouble than tin oxide in this respect.

# Whose side is your lighting on?

## IS EFFICIENT LIGHTING HELPING TO WIN THE WAR BY INCREASING YOUR PRODUCTION, OR IS INEFFICIENT LIGHTING RETARDING YOUR OUTPUT?

**LIGHTING — EXPERTLY PLANNED — IS A VITAL FACTOR IN WARTIME PRODUCTION**

G.E.C. Lighting Specialists have played an important part in contributing to the speed-up in production in factories of all kinds engaged in the **GREAT NATIONAL EFFORT.**

THE FACTORIES (STANDARDS OF LIGHTING) REGULATIONS 1941, ARE NOW IN FORCE.

*Statutory Rules and Orders 1941. No 94.*

*Make sure your Lighting complies*

*Consult the*

# G.E.C.

**FOR ANY STANDARD OF ILLUMINATION**

*Advt. of The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.*

Enamels containing high fluorine introduced as sodium fluoride may prove satisfactory.

The advantages of the molybdenum ground coat may be summarised briefly as follow:—(1) Lowers cost; (2) covers with less white enamel; (3) reboils very slightly; (4) makes low-temperature ground coats possible; and (5) permits finer adjustment of the ground coat at the mill.

### Conclusions

It has been shown that molybdenum dioxide and antimony trioxide, when milled into a clear enamel base, produce adherence comparable to the typical cobalt ground coat enamels. Soluble molybdenum trioxide plus $Sb_2O_3$ likewise produces adherence, but causes drying difficulties. Other compounds such as the described antimonyl molybdate or barium antimony molybdate may also be used instead of $Sb_2O_3$ plus $MoO_3$. Enamels similar to those used with typical cobalt ground coats appear to give the best results and the use of heavy opacifiers seems to cause a decrease in adherence.

A theory explaining the rôle of molybdenum dioxide and antimony trioxide as mill additions indicates what reactions may take place. Typical enamel batches and mill batches are given, although these may be varied quite generally.

### Addendum

Since the above Paper was presented to the American Ceramic Society, additional information has been developed on the use of molybdenum in enamels. This investigation included further work with molybdenum trioxide, ammonium molybdate, sodium molybdate, calcium molybdate, barium molybdate and lead molybdate as mill additions. It was found that all these compounds can be used to produce adherence of porcelain enamels to steel when used in the presence of antimony compounds in certain types of enamels. The antimony compounds may be added as mill additions or smelted-in. The molybdenum compounds act better when used as mill additions, although in several cases good adherence was obtained when they were smelted into an antimony-bearing enamel. The first three compounds mentioned, molybdenum trioxide, ammonium molybdate and sodium molybdate, are soluble compounds and produce shore lines in dip-drain enamels. These shore lines are not noticeable in slushing and spraying enamels when these soluble compounds are used. Sometimes tearing is encountered with these soluble compounds, although this can be overcome by proper mill additions.

The insoluble compounds, calcium molybdate, barium molybdate and lead molybdate, make excellent mill additions. Of these, lead molybdate is by far the most insoluble, barium molybdate next and calcium molybdate the least insoluble.

Experiments show that barium molybdate acts the best in dip-drain enamels (ground coats). Sodium antimoniate is given preference over antimony trioxide as a mill addition in colourless ground coats, while in opaque ground coats containing smelted-in antimony no mill additions of antimony compounds are necessary.

One-coat coloured enamels for spraying seem to act better with antimony oxide and lead molybdate or ammonium molybdate. Lead molybdate seems to give the best results in white ground coats and one-coat white enamels, although ammonium and sodium molybdates function very well under certain conditions. By using these compounds it is now believed possible to produce satisfactory white ground coats and white enamels directly on steel. Various one-coat coloured enamels are possible in addition to the clear and opaque ground coats previously reported.

(*Continued in next column.*)

(*Continued from previous column.*)

The following is a typical example of one of the new molybdenum enamels:—

Clear Ground Coat at 870 deg. C.

*Empirical Formula.*

$0.15\ K_2O$, $0.60\ Na_2O$, $0.25\ CaF_2$ } $0.15\ Al_2O_3$ { $2.00\ SiO_2$, $0.60\ B_2O_3$

*Smelter Batch.*

| | |
|---|---|
| Borax | 35.50 |
| Feldspar | 26.00 |
| Quartz | 20.50 |
| Soda ash | 6.60 |
| Soda nitre | 5.30 |
| Fluorite | 6.10 |

*Mill Batch (lbs.).*

| | |
|---|---|
| Frit | 1,000 |
| Clay | 70 |
| Borax | 7.50 |
| Sodium antimoniate | 15 |
| Molybdenum | See below. |
| Water | 500 |

Grind: 10 grm. on 200 mesh.
Apply: 30 to 40 gm. per sq. ft.

Based upon a 0.60 per cent. $MoO_3$ addition, the following molybdenum compounds may be used:

| | |
|---|---|
| Lead molybdate | 15.30 |
| Barium molybdate | 12.40 |
| Sodium molybdate | 8.60 |
| Ammonium molybdate | 8.20 |

Eight other enamels for clear, opaque and white ground coats are included in this addendum, but pressure on space prevents their inclusion. They can be obtained by writing to the Climax Molybdenum Company of Europe, Limited, 2 and 3, Crosby Square, London, E.C.3.

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[1] W. L. Housley and R. M. King: "Mechanics of Enamel Adherence, XI, Application of the Theory of Dendritic Adherence to the Development of White Ground Coats for Sheet Steel," Journal American Ceramic Society, 18, pp. 319-20 (1935).

[2] C. R. Amberg, H. D. Prior and J. C. Richmond: "Adhesion of Enamel to Steel Produced by the Electrodeposition of $Mo(OH)_3$ on the Steel," Journal American Ceramic Society, 20, pp. 75-76 (1937).

# The Vitreous Enamelling Industry

By J. H. GRAY, A.M.I.Mech.E.

It is amazing how quickly the various industries have adapted themselves to enable production not only to be maintained but, in most cases, to be increased, in spite of the many visits made to this country by Nazi airmen. It must be witnessed, to appreciate the gameness, "Go to It!" and "Keep at It!" spirit of all.

The vitreous enamelling industry, small as it is these days compared with pre-war, has, in many instances, been badly hampered, but as with the finish produced, so with the industry—"hard and durable." It is still carrying on!

As the writer ventured to suggest in his previous article, much of the equipment in the industry, such as furnaces, sandblast, pickling and spraying plants, etc., which were then idle, has now been put into operation to produce, or is assisting to produce, war materials. In other cases valuable factory floor space in vitreous enamelling plant has been commandeered, and in some of these works, where in pre-war days one would see a really smart spray line and drier unit, the same site to-day is occupied by rows of machine tools operating 24 hrs. per day seven days per week.

This change-over has not been made at the desire of the enamelling industry, but to meet a vital national need, irrespective of the consequences to what is, after all, a semi-luxury trade, and with the knowledge that the technicians in the industry will be retained at the various works and be at their posts so that when there are all the tools necessary to finish the job at present in hand, they will be able to carry on with vitreous enamel research and production and make up for the time lost.

### Industrial Co-operation

It is interesting to note that enamelling plants, temporarily out of production, due to enemy action, have not slowed down the country's output of enamelled products, as many helping hands were, and are, ready to take over production in plants still pushing ahead. In a number of cases arrangements have been made, by two or more plants, for mutual assistance should any one of these be in trouble. This is, of course, to the advantage of all and is of considerable help to the industry as a whole.

Most of the earlier black-out difficulties experienced in plants have now been overcome, and there still remains a percentage of plants operating some of their furnaces 24 hrs. per day.

Whilst the production recently has been inconsistent, it is felt that the production figure, generally speaking, is approximately one-third of the pre-war output.

More of the personnel from the enamelling shops have since joined the services or have been engaged by one of the various Government departments. In one or two recent visits to enamelling plants, and also from correspondence received, it is interesting to see and hear of gas and electric stoves, both new and re-conditioned, reflectors, table tops, etc., still being processed, and the same amount of interest as usual being shown by all the operators. New standard domestic cooking and heating appliances are practically out of production, but most gas and electric stove manufacturers have what is termed a "large apparatus department" where large cookers, steamers, hot-closets, etc., are produced and vitreous enamelled, and it is this side of the stove industry that is maintaining production for the supply of large apparatus under Government contracts.

Although it will be admitted that nobody likes enamelling troubles, it seemed like going home after being away for a long time to hear the terms "black specks," "hair-lining," and "crawling" mentioned again; also to hear the phrases such as "that a really good white, and only 1 per cent. of tin oxide!"

### Export Well Maintained

In spite of the various difficulties being experienced, readers will no doubt be interested to hear that frit manufacturers are still maintaining a considerable proportion of their export business.

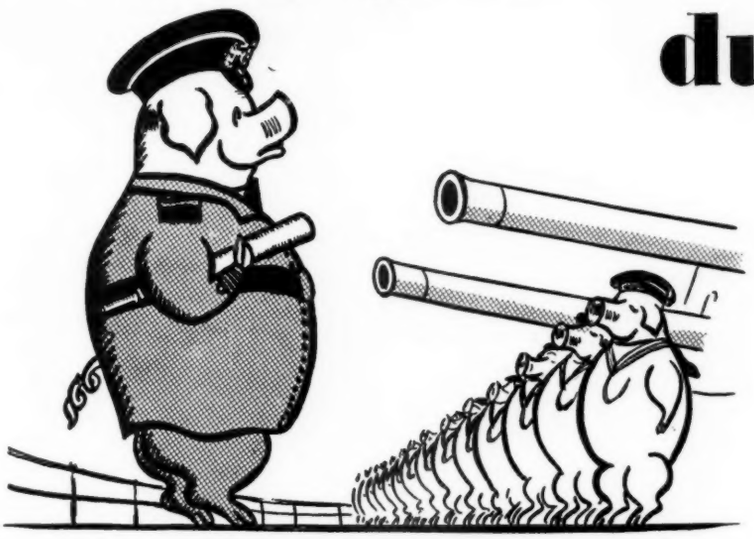
It is interesting to note that frit manufacturers are able to keep busy their reduced manufacturing plants. Those who were fortunate enough to secure raw materials in bulk are now in the most favourable position, as they are able to supply their customers' requirements and have not had to consider the changing of frit formulæ, which is to the mutual advantage of both supplier and customer.

Taking a general view of the industry to-day and bearing in mind the difficulties that exist, it is suggested that its condition is very healthy, and the writer is more convinced than ever that the prospects for the future are extremely good.

After these many months of war, the housewife, and in fact everybody, will, when hostilities have ceased, want the building of new homes, shops and factories made as bright, hygienic and as endurable as possible, and obviously the best answer for this is "vitreous enamel." Pre-war, with the assistance of the Institute of Vitreous Enamellers, the general public were being educated to the great advantages of vitreous enamelled finishes. This should not cease, but after the war it should be carried on with even greater efforts.

(*Continued on page* 234.)

# "Foundries expect every pig to do its duty"



But in actual fact they expect "High Duty" from Warner Pig.

They expect it to provide that extra dependability in a vital casting—that uniformity and closeness of grain—and that certainty of analysis within their closely specified limits.

They expect all this and more because it has been their experience in the past.

They can count on Warner Pig continuing to do its "High Duty" in circumstances which demand the best from men and materials.

## High Duty Pig Irons

## Warner's

## Special Pig Irons

WARNER AND CO. LTD., CARGO FLEET, MIDDLESBROUGH

# The Week's News in Brief

## Trade Talk

SLOW COMBUSTION STOVES, in sizes up to and including that commonly known as the "30 in. by 12 in.," are now liable to purchase tax charges.

THE SINKING of a tungsten and molybdenum mine at an altitude of 7,550 ft. above sea level in the Altai mountains in Russia has recently been completed.

THE INSTITUTE OF WELDING is holding a luncheon at Grosvenor House, Park Lane, London, W.1, on April 23 at 1 p.m. Sir William Larke, K.B.E., will preside.

THE MAY LECTURE of the Institute of Metals will be delivered by Dr. F. Simon at the New Clarendon Laboratory, Oxford, at 3.30 p.m. on May 28. He is taking as his subject "The Significance of Low Temperature Research."

**THE CZECH ARMAMENTS INDUSTRY has passed completely under the financial control of the Reich, and armaments captured at the time of the occupation of the Republic have been sold abroad, mainly to Balkan countries, to provide Germany with foreign exchange.**

**NEW CALEDONIA, the Free French colony in the Pacific, has prohibited the export of chrome and nickel ores to Japan. A representative of the New Caledonia Nickel Mining Company is seeking alternative outputs for these mineral products in the British Empire and the United States.**

MR. W. H. B. HATTON, presiding at the annual general meeting of the Birmingham Exchange, said that when one considered that the country was engaged in the greatest struggle for existence it had ever faced and the fact that industry was rigidly controlled, it was a matter of congratulation that the number of ticket-holders had decreased by only 3 per cent. on last year's figure. The Birmingham Exchange was the oldest and largest which catered for iron, steel, coal and allied industries and non-ferrous metals in the country, and, in spite of restrictions and controls, was still a useful and essential institution for commercial well-being.

SCOTTISH INDUSTRY has made a notable contribution to the fund launched by the Lord Provost of Glasgow, Sir Patrick Dollan, to assist in removing the distress resulting from the blitz on Clydeside in March. Among many notable contributions are the following: Colvilles, Limited, £500; Scottish Iron and Steel Scrap Association, £50; W. Arnott Macleod & Company, Limited, £100; Bairds & Dalmellington, Limited, £2,500; Wm. Beardmore & Company, Limited, £1,000; Yarrow & Company, Limited, £1,000; Alex Stephen & Company, Limited, £500; Scottish Machine Tool Corporation, Limited, £105; John Brown & Company, Limited, £5,000.

TO SHOW APPRECIATION of five workmen who between them have served the company for nearly 250 years, the directors of Samuel Wilkes & Sons, Limited, Excelsior Works, Broxwich, have presented them with gifts, not on retirement, but as a mark of esteem which carried with it a wish that each of the five would long be spared to continue their faithful service. The men are Frank Perry (53 years' service), E. Goodman (51 years'), Howard Banks (51 years'), S. Birch (47 years') and Frank Banks (47 years'). Each one received a framed photograph of themselves with Sir George Schuster, M.P., on the occasion of his recent visit to the works, and a £5 3 per cent. National Defence Bond.

A NOTE from the Commissioners of Customs and Excise on the determination of wholesale value for Purchase Tax purposes states that the value on which Purchase Tax is chargeable is defined as the price (exclusive of tax) which, in the opinion of the Commissioners, the goods would fetch on a sale made at the time when the tax becomes due by a person selling by wholesale in the open market to a retail trader. The definition further contemplates that the goods will be delivered carriage paid. The accountable person or firm will be required to pay tax on appropriations and on all chargeable sales on this level of value, although it may be in excess of the price for which the goods are sold. Information for the guidance of registered traders in arriving at the proper tax value is given in Notice No. 79, obtainable from the local Officer of Customs and Excise. In any case which is not covered by the notice and in cases of doubt, a statement of the facts should be submitted to the local officer or, where a number of registered traders are concerned, direct to the Controller, Valuation Branch, Customs and Excise, Vintry House, Queen Street Place, London, E.C.4.

## Personal

MR. T. MAKEMSON, the secretary of the Institute of British Foundrymen, has changed his private address from 21, Beresford Road, Stretford, Manchester, to "The Woodlands," Hickton Road, Swanwick, Derbyshire.

MR. D. MCNICOLL has been appointed works manager of British Timken, Limited. For some time he was export sales manager. He was recalled from a visit overseas on the outbreak of war and was appointed deputy works manager. He has seen service with other notable engineering companies, including Brown Boveri and Metropolitan-Vickers.

MR. W. J. THOMPSON, of Harborough Hall, Blakedown, Kidderminster, has been appointed Sheriff for the County of Worcester. Chairman of John Thompson (Wolverhampton), Limited, and its subsidiary companies, and governing director of John Thompson (Engineering), Limited, Mr. Thompson entered upon his commercial career more than 50 years ago, and has travelled round the world many times.

### Will

HOWARD, H. E., a director of Stewarts and Lloyds, Limited ... ... £39,760

## Obituary

MR. WILLIAM SLACK, managing director of the Modern Electric Welding Company, Limited, Glasgow, has died as the result of enemy action. Mrs. Slack died with her husband.

MR. THOMAS JOHNSTON, of Anniesland Road, Glasgow, who was known to a very wide circle of trade friends in the country as secretary of Harland & Wolff, Limited, of Scotstoun, Glasgow, has died through enemy action.

MR. FRANCIS EDWIN BROWN, chairman of David Brown & Sons (Huddersfield), Limited, and its associated companies, whose death was briefly reported in our last issue, was well known throughout the engineering industry. He first joined the company, which was founded by his father in 1860, as an apprentice in 1889, and the business of David Brown & Sons in its present form was originated by him. He devoted the whole of his working time and a great deal of what should have been his spare time, to the furtherance of the interests of the company. He was a pioneer in the development of machine-cut gearing, which was a logical outcome of the first machine the company had designed and made for them for cutting teeth in the wooden gear patterns in which they at that time specialised. The next step was the adoption of the same machinery for cutting the teeth in mortice gears, where hornbeam teeth were wedged into cast-iron bodies and the teeth afterwards machine cut. He early realised the possibility of cutting teeth in metal patterns and then in the actual running gears. This led to the acquisition of the site of the present Huddersfield works (Park Works) in 1900. The wide use that is now made of worm gearing is, in no small measure, due to his initiative.

## Contracts Open

**Glasgow**, April 11—Bolts and nuts; brass cocks, etc.; iron pipes, vertically cast or spun iron, and special castings; steel files, etc., for 12 months from June 1, for the Gas Department. The General Manager, Gas Department, 30, John Street, Glasgow, C.1.

**Coleford**, April 15—Provision and laying of about 640 yds. of 8 in. dia. iron and steel delivery mains, for the West Dean Rural District Council. Willcox, Raikes & Marshall, engineers, 33, Great Charles Street, Birmingham, 3. (Fee £5 5s., returnable.)

**Monel Metal**—Monel Notes, No. 23, issued by Henry Wiggin & Company, Limited, of Grosvenor House, Park Lane, London, W.1, contains articles on the forging of this alloy, and the bending of pipes made from Monel metal and related alloys.

## Company Meetings

**British Thomson-Houston Company, Limited**

Stating that they were very busy and doing everything they could in the national effort, MR. WILLIAM C. LUSK, presiding at the annual meeting of the British Thomson-Houston Company, Limited, said that they suffered from an unfavourable and, in the opinion of the directors, an unfair standard period for E.P.T. As a result, the increase in profits shown in the figure of £1,357,516 was more than absorbed by the increase in taxation, leaving a slightly smaller net balance than for the previous year, no part of the increase in profits being left for the shareholders or for strengthening their reserves against a rainy day. If 100 per cent. of excess profits was to be taken in taxation, it was all the more important that the standard period used as the basis for calculating such profits should be a fair one, which it was not in many cases at present.

**Thomas Firth & John Brown, Limited**

LORD ABERCONWAY, presiding at the annual meeting of Thomas Firth & John Brown, Limited, held at Sheffield last week, said the fact that the company's turnover for the year had been substantially greater than that of the previous year was to a great extent rendered possible by the large expenditure that had been made in the last four years. Their production was in an increasing degree absorbed for war purposes, but in striving for quantity they had not lost sight of quality; indeed, he believed that the quality of the products produced at their works had never stood higher. The company's production of engineers' tools had assumed very large proportions, as also had the manufacture of hard metal-cutting carbide alloys, a development which had depended much on the application of modern scientific principles. The company was constantly adding to the range of new products manufactured.

## Reports and Dividends

**Heenan & Froude, Limited**—Interim dividend of 5 per cent. (same).

**Blythe Colour Works, Limited**—Dividend of 5 per cent. (against 20 per cent.).

**Brown Bayley's Steel Works, Limited**—Interim dividend of 5 per cent., tax free (same).

**Federated Foundries, Limited**—Dividend on the 5 per cent. cumulative preference shares.

**Radiation, Limited**—Net profit, after tax, for 1940, £117,969 (against £133,878 for 1939); ordinary dividend of 6 per cent. (same); carried forward, £142,784 (£140,392).

**Midland Electric Manufacturing Company, Limited**—Net profit for 1940, after tax, £45,441 (£48,834); 7½ per cent. preference dividend, £3,234 (£3,656); ordinary dividend of 10 per cent. (same), £8,625 (£9,750); bonus of 15 per cent. (same), £12,937 (£14,625); to reserve, £20,000 (same); carried forward, £33,168 (£32,524).

**British Aluminium Company, Limited**—Net profit, £912,211; brought in, £176,640; income tax, £150,000; debenture stock service fund, £175,000; reserve for depreciation, £50,000; reserve account, £100,000; dividend of 6 per cent. on the preference stock, £90,000; interim dividend of 3 per cent. on the ordinary stock, £90,000; final dividend of 7 per cent., £210,000; carried forward, £194,796.

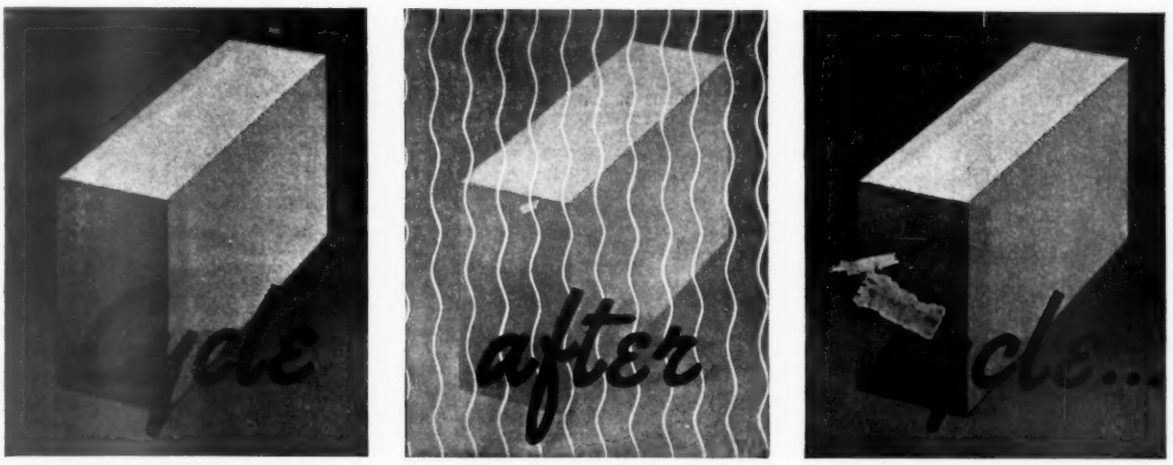
## The Vitreous Enamelling Industry

(*Continued from page* 232.)

When everything is again working on peaceful lines and the enamelling industry is booming—as it must—the industry must congratulate itself, and the public thank the industry for its products.

In days of crisis before the war, those concerns which continued to extend and modernise their plants will later be in a favourable position to push ahead and make the world acknowledge the value of vitreous enamelware.

While difficulties are appreciated, the industry should, whenever time permits, put all its efforts into research and produce even more durable and varied finishes; and think of the many articles which are not, but could be, enamelled with advantage.

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For use in all types of combustion chambers & furnaces operating at high temperatures.

**GLENBOIG SPECIAL CROWN:**
For suspended arch blocks and all blocks subject to thermal shock and high temperatures.

**GLENBOIG:**
Unequalled for general furnace construction, boiler linings, baffles, etc.

**GLENBOIG CROWN:**
For suspended arch blocks, throat bricks—wherever freedom from spalling is the most important factor.

**CASTLECARY:**
General Furnace work, boiler linings, etc.

**GEM:**
All positions where conditions are less severe than those which necessitate the use of first grade Scottish Firebricks.

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For use in secondary positions. Good shape and size.

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A general purpose firebrick, especially suitable for ladle linings in steel works.

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THESE two important factors are provided for in the range of firebricks supplied by General Refractories. An exacting control of the raw materials available from its many firebrick works throughout the country—the use of the most modern equipment—the rigid application of laboratory tests at each manufacturing stage—these ensure a supply of sound firebricks of uniform quality, shape and size. The resources of General Refractories enable them to offer a range of refractories suitable for the execution of any contract. The user may, therefore, depend upon receiving carefully considered and unprejudiced recommendations directed solely to ensure maximum life and dependability from his furnace structures.

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CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline, Plastic K-N., Glendoline, Ground Ganister, Steel Moulders' Compositions.* SILLIMANITE: *Tank Blocks, Bricks and Cements.* SANDS: *Moulding, Brick Facing, Silica, Glass.*

# Raw Material Markets

Supplies of foundry iron of high phosphorus content are coming to hand freely under licences granted by the Control authorities, and some consumers have been permitted to buy beyond the extent of their immediate requirements, which is a concession very welcome to users, who have had to operate on a hand-to-mouth basis over a long period. Better quality irons, such as low-phosphorus grades and hematite, remain somewhat tight, licences being given only to high-priority consumers. Available supplies are being distributed under official guidance, and home outputs are being supplemented by foreign iron, which, although much more costly to buy, is sold to users in the United Kingdom at prices corresponding to those charged for material produced in this country, the difference being made good from the central fund set up for this purpose.

## Pig-Iron

**MIDDLESBROUGH**—Reserve stocks of pig-iron are again making their appearance in the yards of users in the Cleveland area, the supply position being sufficiently sound to permit tonnages to be placed in reserve. There is still almost no foundry iron being produced by local furnaces, consumers relying on the outputs of furnaces in Northamptonshire and Derbyshire. Deliveries from these districts were subjected to a certain amount of delay during the period of traffic congestion a short time ago, but these difficulties now appear to have been overcome, and iron is coming through quite freely. Light foundries are still in need of additional orders, and hopes continue to be expressed that the Government will be able later to hand out more work than has yet been forthcoming from this source. Heavy engineers' order-books, on the other hand, are practically entirely filled with business on Government account, and activity among these concerns may be expected to remain at a high level for a long time to come, the indication at present being that more official work will be made available to these works in the future.

With steelworks in this area using a considerable proportion of the make of hematite, there is little available for distribution among other consumers. Buyers have mostly booked their requirements over the second period of the year at current prices. It had been expected in some quarters that prices would be increased, but no official intimation has as yet been received of any alteration in existing quotations.

**LANCASHIRE**—With the majority of jobbing foundries and light-castings makers rather poorly situated for new business, consumption of pig-iron in these sections is below the average level. On the other hand, heavy electrical engineers, machine-tool makers, and other specialised foundries continue to operate their plant at capacity levels, and demand for iron from these consumers is very considerable. Adequate tonnages are forthcoming from Derbyshire and Staffordshire producers, and all urgent needs are readily satisfied. In addition to the call for common iron, refined qualities are well taken up.

**MIDLANDS**—The heavy engineering and allied trades are still fully booked up with orders for various Government departments, and are able to anticipate full-scale operations over some months ahead. Consequently, the demand for low-phosphorus iron and hematite is maintained; owing to a certain amount of difficulty in obtaining all requirements of these grades, many works have been able to make increasing use of high-phosphorus iron and refined qualities, which are more freely available. Light-castings makers and other users of high-phosphorus iron are able to procure all their requirements and are even allowed to purchase in excess of their current needs, so that useful stocks are being laid down. Business in the light-castings branch remains somewhat dull, although there is quite a good flow of orders for builders' castings. Works which have been able to adapt their plant to cope with the requirements of Government departments are naturally better situated than those relying upon ordinary domestic business, but this trade is not yet called upon to take a very active part in the war effort.

**SCOTLAND**—The rate of deliveries to urgent consumers of pig-iron is sufficient to enable users to operate without interruption, but there is room for considerable improvement in this respect. Consumption is particularly heavy among the specialised branches of engineering, which are in possession of large orders from Government departments. Trade in the Falkirk and district light-castings industry, on the other hand, is no more than moderate, and it is noticeable that many workers formerly employed in the area have left to seek employment elsewhere. Demand for steel-making iron is insatiable, but sufficient iron is forthcoming to prevent loss of output.

## Coke

A steady flow of deliveries of foundry coke continues to be reported, and the needs of all consumers are being met without delay. Producers are willing to supply buyers with additional tonnages for stocking purposes, a concession of which many users have taken advantage. The current official minimum quotation is 61s. 6d. per ton for Durham best foundry coke, delivered Birmingham and Black Country stations.

## Steel

The British steel industry has every reason for self-congratulation on its present position. True, it is necessary for the Control authorities to import steel on a substantial scale, but considering the reliance which the industry formerly had upon the outputs of Belgian and other Continental works, it is indeed gratifying that the requirements of consumers are being met so satisfactorily as is the case at the present time. Priority consumers' needs account for practically all the steel which becomes available, and only in very special cases can metal be released for consumers outside this category, while the export trade is restricted largely to the needs of users in the Dominions and Colonies who are co-operating in our war effort.

## Scrap

Pressure for deliveries of iron and steel scrap remains great, and merchants cannot always supply maximum tonnages, despite unabated efforts to bring out for disposal all the old metal that can be utilised for the furtherance of the war machine. Demand from the steel plants is especially keen, while consumption of heavy cast-iron scrap in the ironfoundries tends to increase, and there is some shortage of this material in certain parts of the country.

## Metals

**Copper**—The copper supply situation in the United Kingdom shows little change from week to week: licences for the purchase of fresh supplies are granted only after very careful scrutiny of the applications, as it is necessary to conserve metal for the requirements of the war effort. British orders for copper products in the United States are considerable, while consumption of the red metal in connection with American defence orders is on an ever-increasing scale. It is believed that the Metals Reserve Company, the purchasing agency for the U.S. Government, may buy a third 100,000 tons of copper from South American producers. Some light on the copper supply position in Australia was given in the January issue of the Queensland Government Mining Journal, which stated that in all probability the amount of copper from Australian mines will not last more than about 15 years on a 20,000-ton annual consumption basis, or for 12 years on an annual basis of 25,000 tons. The Journal adds that the wide expansion of munitions output within the Commonwealth is absorbing the full output and, in addition, some imports are necessary. In 1940, production of Australian mines was about 19,500 tons, or the highest for any year since 1923. This figure compares with an average output of approximately 40,000 tons per annum during the last war.

**Tin**—Fairly active conditions have prevailed in the London tin market of late. The Ministry of Supply has offered fairly substantial tonnages for sale, and these have helped to keep quotations steady. Business in the United States has been on a large scale and the current price is well in excess of the Metals Reserve Company's buying price of 50 cents per lb., so that it is assumed that the company's stocking programme has been temporarily interrupted. While tinplate operations in this country have been curtailed, the American industry has become more active, current operations being around 86 per cent. of capacity.

Tin prices on the London Metal Exchange during the past week have been as follow:—

*Cash*—Thursday, £273 15s. to £274; Friday, £274 to £274 5s.; Monday, £272 10s. to £272 15s.; Tuesday, £270 to £270 5s.; Wednesday, £268 to £268 10s.

*Three Months*—Thursday, £271 to £271 5s.; Friday, £271 to £271 10s.; Monday, £269 5s. £269 10s.; Tuesday, £266 15s. to £267; Wednesday, £265 to £265 5s.

**Spelter**—Distribution of spelter continues to be severely controlled in this country, only small tonnages being allocated to buyers after the needs of priority users have been met. Galvanisers and brass mills are busily employed on urgent orders, the former taking up heavy supplies of g.o.b. metal, with the latter in the market for high-grade qualities. It is anticipated that there will shortly be a freer flow of brass products from the United States, although it is unlikely that this will result in any material reduction in the demand for zinc in this country.

**Lead**—Priority demand for this metal tends to expand, but, as yet, there is sufficient to meet the calls from other classes of consumers. Should the requirements of essential users rise very considerably, it is probable that stricter control of distribution will have to be resorted to, but so far there is no indication of this. The American lead market is firm and the price has been advanced to 5.85 cents per lb., New York. Supplies in the United States at the present time are ample, while the output of Mexican producers is at the disposal of consumers should it be necessary to draw upon it.

## Patent Specifications Accepted

*The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.*

528,097 STEVENS, A. H. (Roger Foundry & Machine Company). Apparatus for cleaning and aerating moulders' sand.

528,112 POTTS, H. E. (Atack, F. W.). Electrolytic production of manganese.

528,185 ELLIS, L. S. E. (United States Steel Corporation). Method of making steel.

528,331 WHITE & SONS, LIMITED, W. B., and WHITE, W. P. Machine for breaking up metal turnings and cuttings.

528,549 TAGLIAFERRI, L. Electric arc furnaces.

528,558 ABELL, C. D. Treating metals to provide a coating or film thereon.

528,565. CUTANIT, LIMITED. Hard metal alloys.

528,576 MILES, J., and BRASSERT & COMPANY, LIMITED, H. A. Clay guns.

528,578 CLARK, F. H., and DIRKES, R. F. Methods of producing steel, and compositions for use in such methods.

528,625 JONES, W. L. (Hayes, C. I.). Heat treatment of metals.

528,626 EFRAIMOVITCH, Y. Automatic regulator for arc furnaces.

528,845 TITANIUM ALLOY MANUFACTURING COMPANY. Zircon refractories, and methods of making same.

529,247 NATIONAL STANDARD COMPANY. Stainless steel articles or objects, and methods of treating or eletroplating stainless steel surfaces.

529,259 SOC. ANON. DES TUBES DE VALENCIENNES ET DENAIN. Manufacture of seamless tubes on a pilger step rolling-mill.

529,312 LOBKOWITZ, G. B., and STEELWORKS DESIGN, LIMITED. Universal rolling-mills.